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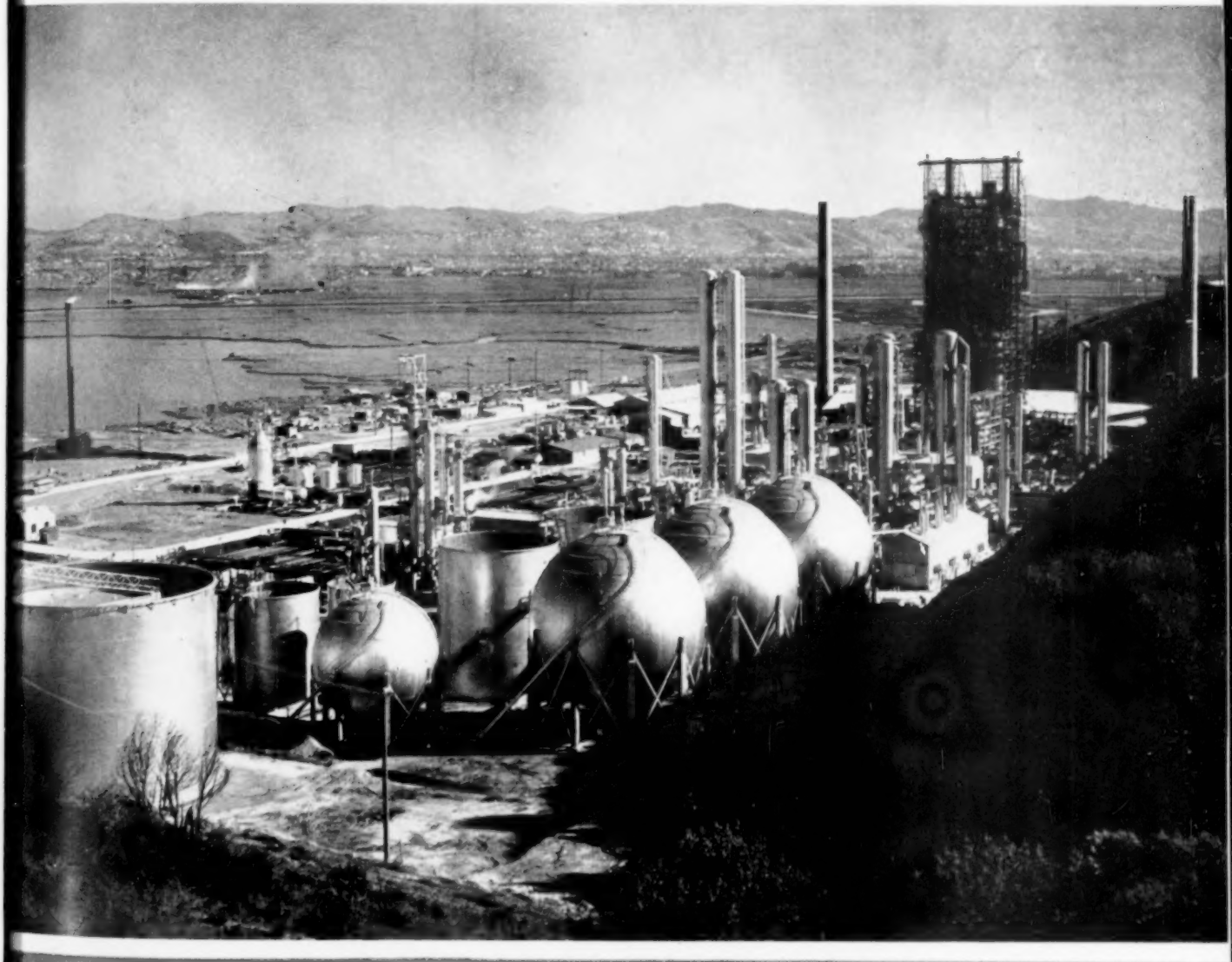

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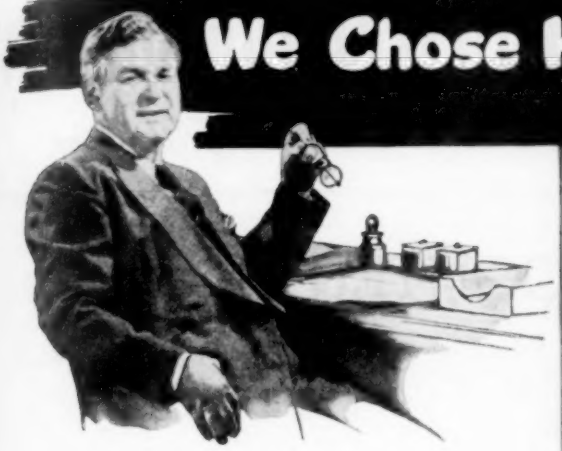

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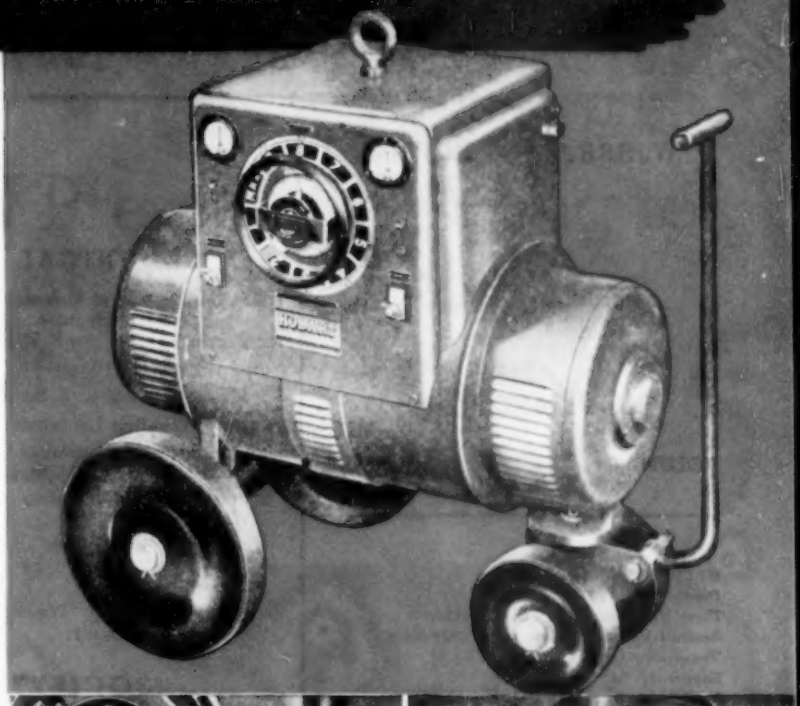

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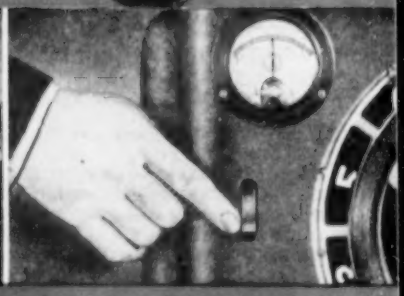

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Published for the Advancement of the Science and Art of Welding

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NOVEMBER, 1945

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The Application of Pressure Welding to the Manufacture of Aircraft Landing Gear*

By E. R. Proctor†

WHEN man first discovered metals and methods of refining, he was quick to take advantage of them for construction purposes. From the earliest times, metals and their uses had a direct bearing on the progress of civilization. As human knowledge developed, the practice of science changed from striving to convert all base metals to gold, and was directed into the field of improvement and development of metals and alloys that could be used in the interest of progress.

By the Nineteenth Century, man had reached the point of being completely dependent on metals for his well being. Many metal working processes were available by that time, but joints of metal were still rather crude and bulky, with the resultant limitations in design.

In view of the present, almost universal use of the Oxyacetylene Welding process, it is difficult to realize that the entire commercial development of the process has taken place within this century.

Early in the Twentieth Century, a tool which has proved its worth in the present conflict and also in the last war, was presented to metal workers and manufacturers who were quick to adopt and develop its many uses and applications.

First used in simple welding, largely for repair purposes, the growth in the scope of application to all types of construction has been phenomenal. Welding rods, fluxes and techniques have been developed to such an extent, that today practically any metal may be joined by welding, with excellent results.

Welding is usually considered a fusion process. The edges to be joined are melted by suitable means of heating, and flow together with or without the addition of other metal, and are joined by the solidification of this molten bond that has been caused to flow between them.

Within the past few years, a new process of welding has been made available to industry. This process known as "Oxyacetylene Pressure Welding" is a semiautomatic process, and has been discussed in several published articles.[1] The process has been used for some time in the welding of railroad rails and overland pipe line. A theoretical discussion of the metallurgical and physical aspects of this type of welding was included in the "Comfort A. Adams Lecture" given to the AMERICAN WELDING SOCIETY in 1944.[2]

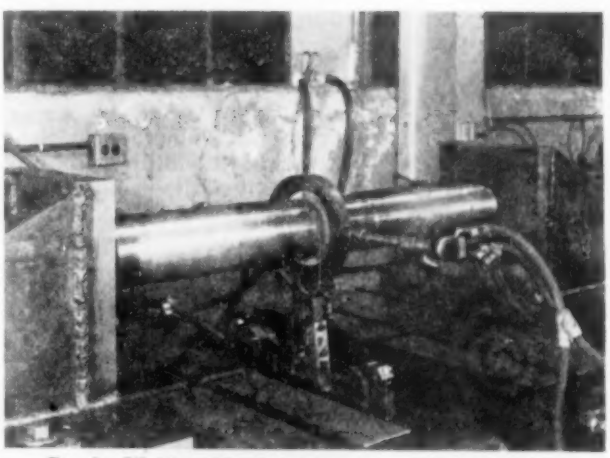

Fig. 1—Welding Head in Operation on 6-In. Machine

Oxyacetylene Pressure Welding differs from all other gas welding processes, in that the weld is made, not at liquid or fusion temperature, but by coalescense of the grains across the weld interface at subfusion temperatures, under the influence of controlled temperature and pressure. The weld is accomplished by abutting the clean square faces of the two sections to be welded under a specific pressure and heat which is applied by means of a multiple flame head (Fig. 1) which directs heat at the weld plane until upsetting occurs.

The completed joint has a definite bulge or upset at the weld, varying in height with the thickness of the metal being welded. The process is ideally adapted to semiautomatic or fully automatic control, and is therefore capable of a high degree of uniformity and accuracy.

The method used to control the quality of the weld obtained by this process is of great importance, as upon proper control depends the consistency and quality of the welds produced. To understand the control methods, it is necessary to understand the entire welding procedure.

In the commercial application of the process, the ends to be welded are machined to a smooth, clean surface.

* Scheduled for the Twenty-Sixth Annual Meeting, A.W.S., October 1945.
† Development Engineer, Menasco Manufacturing Co., Burbank, Calif.

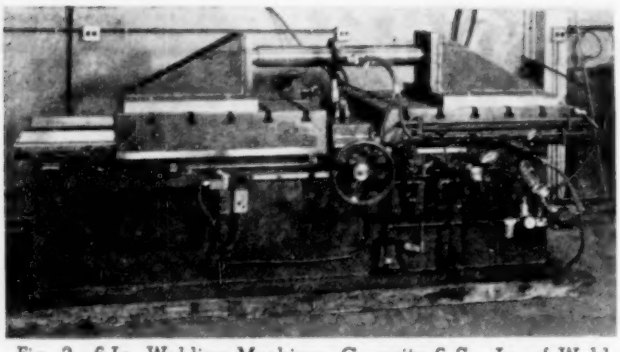

Fig. 2—6-In. Welding Machine; Capacity 6 Sq. In. of Weld Area

For the average low-carbon steel, the principal requirement is cleanliness.

The opposing pieces are lined up carefully, after which the welding pressure is applied. The blow pipe, or heating head, is lighted and adjusted to predetermined gas pressures. After the metal reaches approximately the welding temperature, the metal parts start to upset gradually. The process continues with the temperature gradually increasing, during which time a predetermined degree of upset is produced, then the flames are extinguished and the end pressure relieved.

Discussion

During 1941, the major aircraft manufacturing companies were carrying on experimental and research work in the use of butt welding applied to the manufacture of landing gears, in order that a considerable reduction in weight could be achieved. To expedite the program, and bring the best qualified personnel into it, the major landing gear manufacturers were requested to also investigate the possibilities of butt welding.

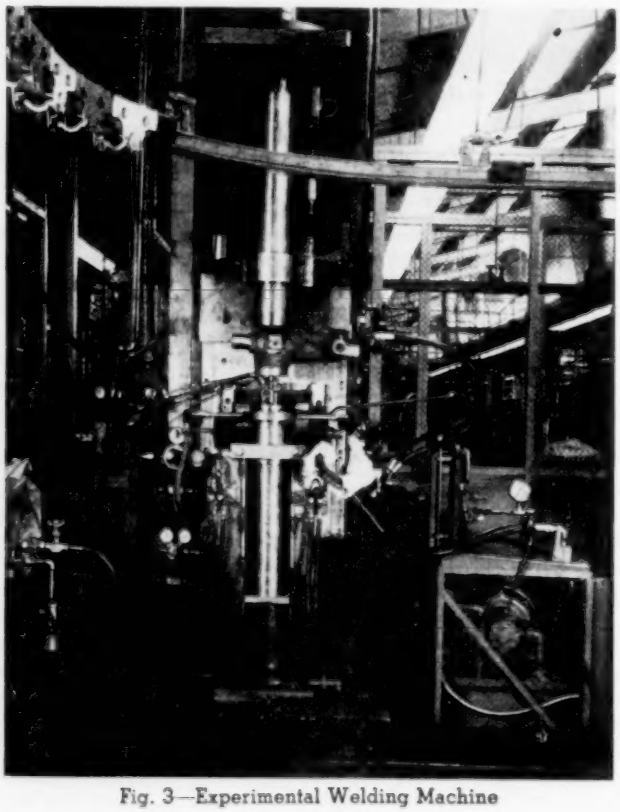

Fig. 3—Experimental Welding Machine

The first pressure welds to be examined were made by the Hydril Corp. of Los Angeles. These welds were examined and tested by the Menasco Manufacturing Co. at Burbank, Calif. The results pointed out that the process had possibilities in advancing the art of landing gear design, and would improve the manufacturing methods used. Consequently, a research and development program was instituted by Menasco Manufacturing Co.

In order to differentiate the process as applied to the aircraft industry from the process as it is being used commercially, the name "Uniweld" has been adopted by the Menasco Manufacturing Co., to identify the type of pressure welding that is in use in the manufacturing of landing gears.

The preliminary investigation was made with specimens that were welded on an experimental welding machine (Fig. 3) which was constructed for temporary use. Machine design from an engineering standpoint was started in the early stages of the program. The result of this engineering study is a complete range of welding machines that are capable of welding tubular joints in sizes ranging from 1 in. diameter up to and including 20-

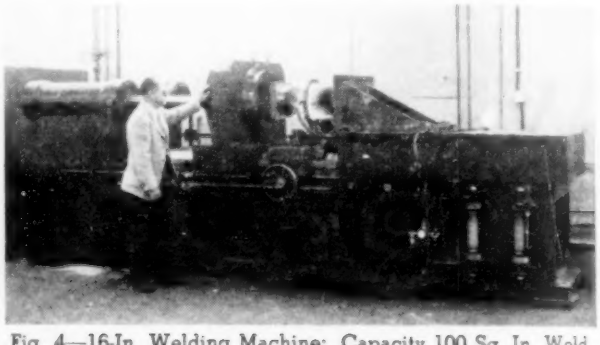

Fig. 4—16-In. Welding Machine; Capacity 100 Sq. In. Weld Area

in. diameter tubular joints. The production 6-in. welding machine is shown in Fig. 2.

In studying an ideal cycle of this welding process, it will be seen that the instantaneous temperature of the specimen, the rate of temperature rise, the time, the total gas flow and a degree of upset with its attendant shortening of the specimens, are all variables. By the same token, they provide values that may be measured and may be used as means for indicating the progress of the weld. However, consideration from a practical standpoint indicates that other factors enter which would lessen the degree of reliance that could be placed on some of the possible methods of control. For instance, a draft of cool air may affect the time required to raise the metal to a predetermined temperature, or the original temperature of the steel might vary over a considerable range. These variations exclude the use of total gas consumption or total time as a means of control.

Temperature measurement has not proved a reliable method of measuring the progress of the weld. However, the degree of shortening or amount of upsetting of the metal at the joint under conditions of constant pressure and heat input have proved to be an excellent means of measuring the progress of the weld, and also an entirely satisfactory method of control. It is a relatively simple matter to control, by electrical means, the amount of shortening in the parts being welded, therefore, this method is being used universally as a means of control.

In the development of welding controls that would make possible the consistent duplication of welds that would meet the stringent requirements of the aircraft industry, it was obvious that more accurate means of

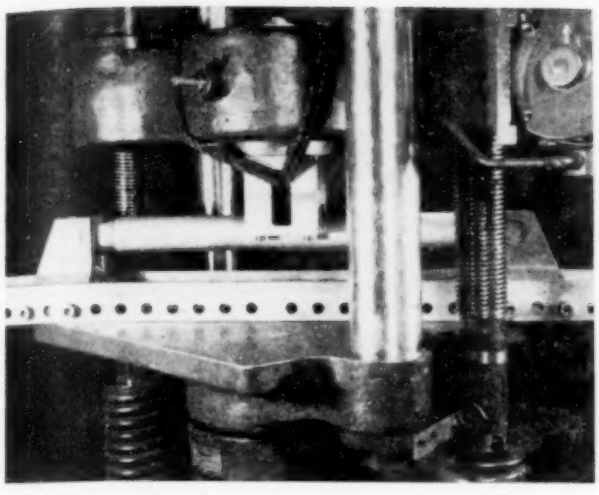

Fig. 5—Tube Shown in Position for Testing

control must be used than those which were in general use throughout industry.

It was pointed out in the discussion of the procedure of the welding process, that the ends to be welded were machined to a smooth surface. The necessary quality of end preparation was found to be dependent on the composition of the base metals being welded, and the expected strength efficiency of the weld. For the high carbon and more particularly the alloy steels, very close mating, as well as rigid adherence to cleanliness, must be observed if 100% efficient welds are to be produced. During the investigation, it was found that by depending on pressure regulators alone in the oxygen and acetylene lines, it was not possible to consistently reproduce flame conditions that were acceptable. In order to overcome this deficiency, flow meters were installed on the downstream side of the pressure regulator, and adjustments in the flame were made from the flow meter readings rather than the pressure regulators. In this manner, it was found possible to consistently duplicate flame conditions and produce acceptable welds.

After finding it possible to consistently produce welds that would meet the strength requirements, the next problem encountered was that of developing an acceptable inspection method. At the present time, an inspection method consisting of machining and magnetic inspection is being used with a relatively dependable correlation of results. This method of examination consists of the acceptance of the theory that the weld progresses from the exterior to the interior of the section being welded. It is assumed that if, by removing a portion of the internal upset and magnafluxing, and no indications were seen, then the weld would be of good quality. To further insure that any poor weld zone would not remain, the remaining upset is then removed.

Because of the fact that the major stresses in landing gear occur in bending, it was decided to use bend tests of full size sections as a means of evaluating welds. The quality of the weld must be such as to meet the following requirements.

1. Bend test specimens shall be loaded in bending to approximately the yield point (based on the ANC5 Modulus of Rupture Chart for strength of tubes in bending) in four positions 90° apart. The test load shall be sustained in each position for 30 sec.
2. Each specimen, after proof loading in four positions, shall be loaded to failure. An internal magnetic indication shall be located on the tension side when loading to failure.
3. Fifty per cent of acceptable bend test specimens shall not show failure in the welds.
4. No bend test specimen shall be acceptable when failure is below 90% of the average ultimate load of all the bend test specimens that fail outside the weld.
5. No bend test specimen weld failure shall be acceptable when such failure is below the average of all acceptable bend test specimen failures.
6. Test loads shall be corrected for tensile strength as indicated by Brinell hardness.

How well these conditions are being met can be seen by the tabulated results of three different size welds that are given in Tables 1, 2 and 3, and also the results of a test production run of 100 parts in which all specimens exhibited the required strength.

Table 1—5.065-In. O.D. x $^{9}/_{32}$-In. Wall

Specimen No.	Approximate Tensile Strength, Psi. × 1000	Modulus of Rupture, Psi. × 1000 — Parent Metal	Test Results	% Parent Metal	Failure
149	180	220	260	118	Buckling
150	175	213	247	116	Buckling (followed by weld failure)
151	180	220	258	117	Buckling
176	180	220	258	117	Buckling
177	175	213	256	120	Buckling
179	180	220	252	115	Buckling (followed by weld failure)
180	180	220	255.5	116	Buckling
181	180	220	255.5	116	Buckling
183	180	220	259.5	118	Buckling

Table 2—2 $^{7}/_{8}$-In. O.D. x $^{5}/_{16}$-In. Wall

Specimen No.	Approximate Tensile Strength, Psi. × 1000	Modulus of Rupture, Psi. × 1000 — Parent Metal	Test Results	% Parent Metal	Failure
TO208	182	270	292	108	Buckling
TO221	182	270	292	108	Buckling (followed by weld failure)
TO222	182	270	289	107	Buckling
TO223	182	270	290	107	Buckling
TO224	182	270	285	105	Buckling
TO225	182	270	291	108	Buckling
TO226	182	270	291	108	Buckling
TO227	182	270	286	106	Buckling
TO228	182	270	285	105	Buckling (followed by weld failure)

Table 3—5-In. O.D. x $^{1}/_{4}$-In. Wall

Specimen No.	Ultimate Tensile Strength (Psi.) by Rockwell "C"	Moment Arm In.	Machine Load, Lb.	Test Modulus of Rupture $f = Mc/I$, Psi.	Army Modulus of Rupture, Psi.	% Army Modulus of Rupture
TO469	192,000	$21^{1}/_{16}$	112,250	279,500	232,000	120
TO471	192,000	$21^{1}/_{16}$	111,500	277,500	232,000	119
TO473	192,000	$21^{1}/_{16}$	111,750	278,250	232,000	120
TO474	192,000	$21^{1}/_{16}$	112,000	279,000	232,000	120
TO475	192,000	$21^{1}/_{16}$	111,500	277,500	232,000	119
TO477	192,000	$21^{1}/_{16}$	111,250	277,000	232,000	119
TO478	192,000	$21^{1}/_{16}$	112,250	277,000	232,000	119

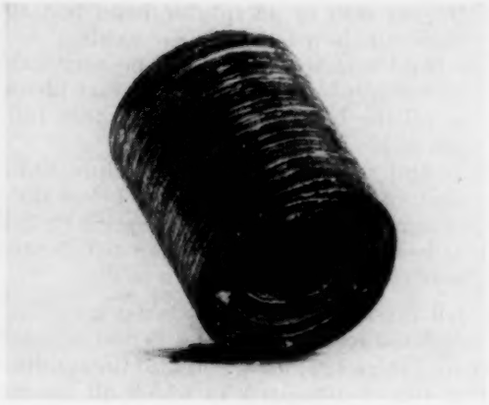

Fig. 6—Chip Cut from Internal Upset of Uniweld. Magnification 4 ×

The general procedure used to develop the technique for a particular weld is as follows:

Test Specimens

(*a*) Uniweld test specimens shall be made for preliminary research in the following sequence before flight welds are produced:

1. Metallurgical test specimens.
2. Bend test specimens.

(*b*) Uniweld test specimens shall be made for each size and condition of flight weld.

(*c*) Each test specimen shall be so numbered for identification that any flight weld may be produced under the exact conditions as recorded from the accepted test specimens.

(*d*) All pertinent data for each test specimen shall be recorded by a member of the Metallurgical Dept. and shall include the following:

1. Date.
2. Operator.
3. Uniwelder adjustments.
4. Heating head size.
5. Heat number identification of steel.
6. Basic outside diameter and wall thickness at the section to be welded.
7. Condition of weld faces.
8. Alignment of weld faces.
9. Size and condition of chamfer.
10. Weld time.
11. Gather.
12. Weld number.

Metallurgical Test Specimens

(*a*) Visual and microscopic examination of the metallurgical test specimens:

1. Flow lines shall not show sharp folds.
2. Weld shall show no cratering or burned areas extending below the clean-up depth.
3. The tube shall show no signs of belling.
4. Structure recovery shall be complete after twice reheating the weld above the critical temperature.
5. Examination of the weld plane zone at high magnification shall show a structure typical of a satisfactory weld.
6. Evidence of internal fissure shall not be found at a depth greater than the finished flight weld I.D.

(*b*) Tests for hardness, tensile strength, ductility and impact shall be made only at the option of and as specified by the customer and shall not alter the bend test specimen procedure.

(*c*) An acceptable metallurgical test specimen shall be completed before proceeding with the bend test specimens.

Bend Test Specimens

(*a*) Bend test specimens shall be Uniwelded in accordance with the recorded data of the approved metallurgical test specimen.

(*b*) Bend test specimens shall be symmetrical about the weld plane and shall have a span depth ratio of 6 to 8.

(*c*) In case the upset is completely removed and the wall thickness reduced, the comparable bend test specimen shall be machined to the same dimensions as the flight weld.

(*d*) In case the wall thickness of a flight weld remains as-welded with the internal and external upset partially removed, the comparable bend test specimen upset height shall be reduced by machining to within a distance from the original wall before upset equal to 10% of the wall thickness but not to exceed 0.015 in.

(*e*) In case the wall thickness of a flight weld remains as-welded with the external upset partially removed but the internal upset remaining as-welded, the comparable bend test specimens shall be machined as specified in paragraph *d*, and two extra specimens shall be machined to the flight weld dimensions and tested.

Testing

The specimens must pass the requirements referred to under the quality of the weld.

One of the developments made as a result of this welding research is a laboratory method of examination that can be applied to other types of welding.

It is a well-known fact that oxygen in solution near the surface of a sample of steel tends to prohibit further oxidation. It is also known that strong alkaline solutions with the addition of certain anions will produce an oxidized film on the surface of steel and that this film is prohibited from forming by the presence of sufficient oxides in solution at such a surface. It was suspected

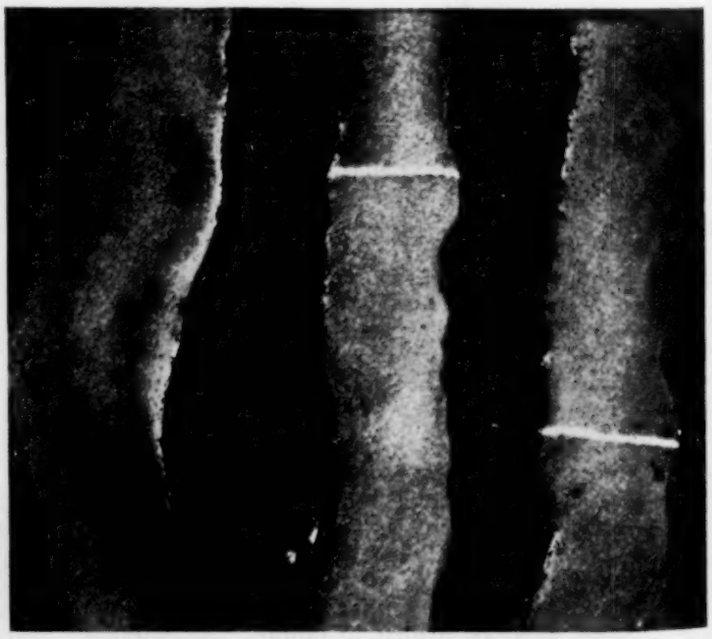

Fig. 7—Cross Section of Chip Taken from a Poor Weld Showing White Zone. Magnification 100 ×

Fig. 8—Cross Section of a Chip Taken from a Good Weld Showing Absence of Any White Zone. Magnification 100 ×

that the weld plane of a poor weld contained a high oxygen content and in a sense represented an area already oxidized. With this in mind, it was thought reasonable to try using strong alkaline solutions containing various anions as an etching agent. A cross section of the weld when etched with such a reagent should form an oxide coating, in general, but not on the weld plane of a poor weld since this weld area had previously been oxidized and therefore would prohibit oxide formation on it. A complete analysis and discussion of this theory which was developed by the Menasco Laboratory is scheduled for publication at an early date.

If it were possible to examine the weld plane without destroying the welded assembly, we would have an ideal inspection method. It was found that by removing a continuous chip of steel (Fig. 6) from the upset on the inside of the weld, and by cutting this chip through the center, that it was possible to examine the weld plane progressively from the inside of the weld to the last portion removed.

Figure 7 shows the cross sections as seen with a poor welded zone which can easily be detected by the white zone present that has been brought out by the etch that was discussed in the theory presented on the detection of oxides in steel.

Figure 8 shows the last portion removed from the weld in which there is no indication of a poor weld or oxides present. This is conclusive evidence that the weld will pass any tests to which it may be submitted.

It is very interesting to note the weight-saving possibilities of this process as applied to the manufacture of landing gears. In the design of a landing gear for an airplane weighing 18,000 lb., the original gear weighed 201 lb., and the gear that was welded by this process only weighed 150 lb., or a saving of 51 lb. The average weight saved by incorporating Uniwelding into landing gear design has been in all cases at least 20%. Simplified design is shown in the clean lines of the experimental gears that have been designed and built by Menasco Manufacturing Co. with the use of this welding process.

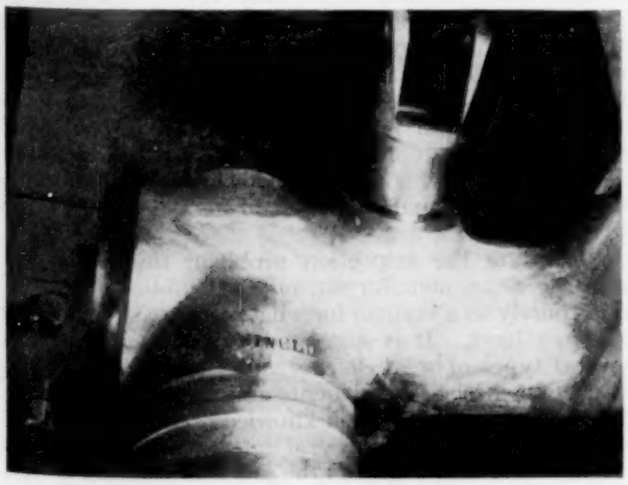

Fig. 9—Forging Uniwelded to Tubular Member

Summary

When the entire story of the application of pressure welding can be told, it will be seen that the contribution to the war effort has been tremendous, not only in the saving of weight on military aircraft, but in the speeding up of many other operations throughout the war industries, where quality and accuracy of welding is of prime importance.

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DISCUSSION

By E. P. Jones*

Mr. Proctor's ably prepared paper, covering the use of the still somewhat new pressure welding process in the manufacture of aircraft landing gear, presents many points of interest to the welding field. The development of this application parallels to some extent work carried out by the writer and his associates of the Pressure Weld Co. on overland pipe lines, and so proved of particular interest.

Naturally, any process which can effect substantial savings in weight in the manufacture of aircraft assemblies will be welcomed by the aircraft industry. However, in order to produce assemblies in quantity, the process must be relatively automatic, leaving little to operator skill. In order to achieve both of these requirements with a welding process on high-strength, alloy

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aircraft steels, the Menasco Manufacturing Co. has overcome considerable in the way of obstacles. In the writer's opinion the most significant attainment in this development was the establishing of a method of weld quality control acceptable to the aircraft industry and to the United States Army.

To date, no convenient and thoroughly reliable nondestructive test has been developed for use with the pressure welding process (or for any welding process, for that matter). The destructive tests developed for fusion welds are not well adapted to the pressure welding process either, having been developed to reveal faults known to occur in the fusion type of weld joint.

The pressure weld, being formed at subfusion temperatures, automatically eliminates many of the faults of the fusion weld, such as porosity, inclusions, laps, pipes, fish eyes, etc. By so doing, it has also eliminated X-ray and gamma-ray inspection as a means for determining weld quality. Other inspection methods such as the magnetic types, show promise; but to date have not proved thoroughly reliable.

As the result of the above, close control of the factors producing the pressure weld were necessary, supplementing these as closely as possible by metallurgical examinations and destructive tests on full size specimens. In this connection, the use of the calculated value for the modulus of rupture of the tubular specimen, as a basis of acceptability of the welded assembly, has considerable merit. By testing the full size specimen in simple bending, all sections of the weld are stressed in a manner which approaches the loading applied to the assembly in service. Any test which can be applied, similar to service loading, gives proof that is hard to dispute.

The methods described for controlling conditions during the welding operation, are somewhat standard for machine pressure welding setups, except for the use of flowmeters in the oxygen and acetylene lines. These provided more sensitive control of gas flow than could be obtained with standard methods of regulation. The writer has witnessed, however, cases of extremely close gas flow control where extra stages of regulation were added to the standard type of gas regulators.

The use of the electric Limit switch for controlling the end point of the pressure weld cycle has become standard practice for pressure welding machine operation. On overland pipe pressure welding, the amount of upset formed on the inside of the pipe is of much importance from a flow restriction standpoint, and must be controlled to close limits. The electric method has proved quite successful for this, by providing accurate, uniform control.

Many tests have been made on pressure welds in an effort to determine the nature of faults produced by improper welding conditions. The results of these tests indicate that the usual defect generally appears as lack of welding at the extreme inside edges of the weld interface. While easily corrected, this condition is sometimes difficult to detect without resorting to destructive tests. The use of nick-break fractures is made at frequent intervals in pipe-line work. This allows visual examination of the grain structure throughout the cross section of the weld, and any lack of penetration is revealed at once. The use of the chip examination by Menasco apparently produces excellent results without the necessity of destroying the welded assembly in the process. However, this procedure undoubtedly requires close control of machining operations in order to yield satisfactory test specimens each time.

To summarize this discussion, it appears to the writer that the Menasco Manufacturing Co. and E. R. Proctor have employed every opportunity to establish a sound basis for the manufacture of aircraft landing gear, utilizing a relatively new welding process to its best advantages.

DISCUSSION

By Alfred Z. Boyajian*

As pointed out by E. R. Proctor, Uniwelding offers many important advantages when used in the fabrication of aircraft landing gears. Most important of these advantages are:

1. Saving of weight.
2. Saving of production time.
3. Saving of manufacturing costs.
4. Greater flexibility in basic design.

With advantages such as these, this welding process is bound to find widespread application in aircraft design.

However, in considering the advisability of using a butt-welded joint in a landing gear, the airplane designer must take into account the following factors in addition to the above. A butt weld comprises the entire strength of a joint and it must work at very high stresses (200,000–350,000 p.s.i. bending modulus of rupture) with relatively small factors of safety. Also, such a joint is not subject to simple visual inspection procedures which are satisfactory for conventional telescoping and bolted landing gear joints. Therefore, the airplane designer's chief concern is the reliability of the weld. He must feel that each and every production weld will have satisfactory strength characteristics, with the emphasis on "each and every weld." There can be no exceptions nor even doubtful cases.

For these reasons it is gratifying to note that throughout his entire paper Mr. Proctor has used as a basis of discussion a high standard of quality control. Beginning with the design of a Uniwelding machine and its controls, and proceeding with weld sample preparations, welding operation, qualification run and the inspection of finished production Uniwelds, Mr. Proctor has kept in mind the final objective of 100% consistency of flight welds.

Somewhat delaying the widespread adoption of butt welding by the aircraft industry is the fact that a dependable inspection procedure of a finished production weld still remains to be conclusively demonstrated. Ordinary inspection methods have so far proved inadequate. Mr. Proctor throws light on a new inspection method consisting of a metallographic examination of the weld metal. This method is not only very interesting, but appears to have considerable merit. It is understood by this writer that Menasco Manufacturing Co. has already used this method with a high degree of success in a number of cases. However, it is not known at this time whether or not for practical reasons the metal chip can be sectionalized at intervals as frequently as necessary. Nor is it known whether or not this metal chip will reveal the presence of small cracks at or near the plane of the weld.

Regarding the inspection problem, this writer, admittedly not a metallurgist, offers the following suggestions purely as a layman for whatever merit they may or may not have. It is suggested that perhaps there are several types of weld defects and that perhaps no one inspection method is adequate for all types of defects. For example, it is common knowledge that magnetic inspection will very often reveal defects in the weld. Also very often it fails to reveal the presence of other defects.

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This indicates that magnetic inspection is good as far as it goes, but is incomplete because the nature of the defect apparently varies beyond the capability of this inspection.

Therefore, for a beginning it is suggested that perhaps all weld defects may be classified broadly into two general types, making necessary two types of inspection. One type of weld defect is that characterized by the presence of cracks, or fissures, or physical discontinuities at or near the surface of the weld. This type of defect may be detected by magnetic inspection, "black light" inspection and by any other method that will reveal physical discontinuities.

The second type of weld defect is one which has physical continuity, but one where the material in the weld zone has experienced deterimental chemical and/or metallurgical changes. This type of defect may be detected by some means of metallographic examination of the weld metal structures such as the one Mr. Proctor suggests.

Since each type of weld defect occurs at irregular frequency, either singly or in combination, possibly neither type of inspection will be complete in itself. Therefore, both types of inspection may be necessary, each supplementing the other.

The static test method of a butt-welded joint outlined by Mr. Proctor, wherein a whole weld specimen is tested by bending successively in four directions, is one of the most rugged tests conceivable. By this test there is little or no chance for a small weld defect to go by undetected. If a small defect existed in the periphery of a weld, by the system of rotation outlined by Mr. Proctor, this defect would eventually find itself on the tension side at or near the extreme fiber in bending where it will greatly influence the total strength of the welded joint. Such sensitivity to a defect would not exist in standard pull test specimens.

The amount of bend test samples preparatory to a production run and the type of final inspection will in time be dictated by experience when a good statistical background becomes available.

In closing, this writer who is somewhat acquainted with the background of research which was necessary to develop the Uniwelding process, can say that a great deal of credit goes to Mr. Proctor and to Menasco Manufacturing Co. They have spent a vast amount of time and effort to develop new welding equipment, to isolate and determine the effect of many important factors influencing the qualities of butt-welded joint, and to develop satisfactory inspection techniques. That they have been successful in their endeavor to produce consistently good welds is evidenced by the fact that in a recent survey of butt-welding processes for aircraft landing gears, their Uniwelding process showed by far the greatest strength consistencies, and actually they proved to be in a class by themselves.

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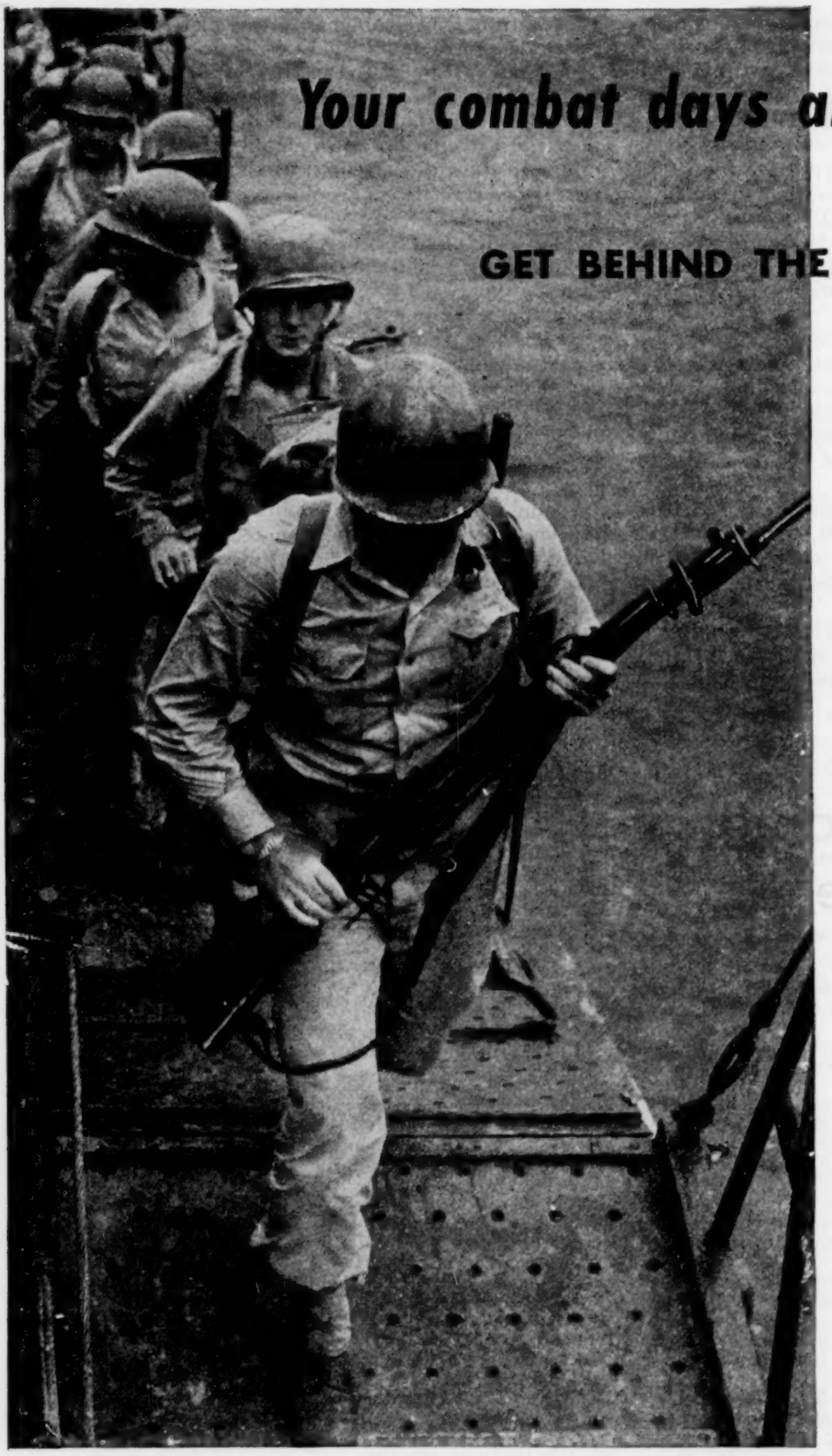

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Maintenance and Repair of Oil Pipe Lines*

By Oliver Wildman†

THE work involved in repair and maintenance of oil pipe lines is not affected greatly by contraction or expansion due to welding. Practically all welding is done with A.W.S. E6010 class electrodes. The gas-welding process is used in very little maintenance and repair work. It is not my intention to convey the idea that procedures and methods of repair mentioned in this paper are used by all pipe line companies. Since a pipe line must extend from an originating point to its destination, covering terrain of different composition and profile, no two maintenance or repair jobs entail the same procedures even though the cause of the injury is the same. It has been acceptable for our foremen and welders to devise and work out the various methods required to maintain and repair the lines as safely and permanently as possible.

An oil pipe line consists of two main parts, the gathering system and the distributing or main line system. The gathering system can be broken down into two parts which are branch lines and main gathering lines. These gathering lines are the arteries of the fields through which the oil is transported to a main line station. The size of the pipe used depends on the size of the field it serves and the length of the line. In this district we have approximately 500 miles of pipe in the gathering and main line systems ranging in size from 4½ in. O.D. to 14 in. O.D.

A branch line, usually 50 to 1000 ft. long, from the main gathering line to the producers' tanks consists of all pipe, connections and fittings outside the stopcock on the tank. The line is connected at the tank with a union (screw-end type) or a bolted coupling using a rubber gasket. The check valve and block gate valve are usually screw-end type valves. Replacing impaired gaskets is done by unbolting the coupling, placing a new gasket, and bolting the coupling again. When a valve becomes corroded or worn it is cut out of the line, nipples are screwed into each end of a new valve, and it is welded into the line. Since it is possible to block the oil at each end of a branch line, there is little or no oil to contend with on any work done on these lines.

This company gravitates probably 90% of the oil run in its gathering system. This enables them to use lighter weight pipe (due to the low pressure) and few booster pumps and pumpers. Pressure on the few gathering lines located where a pump is needed does not exceed 300 psi. Most of the main lines are pumped from station to station under pressure from 300 to 1200 psi.

Since gravity lines follow the profile of the country, they are laid in whatever soil formation is encountered in construction of the line. These lines may go through old oil well slush pits or alkaline formations, or salt water pits may be constructed near the line from which water seeps down to the pipe. Close watch is kept on the pipe in the vicinity where these conditions are known to exist. Breaks in the dope and paper allow moisture to come in contact with the pipe. When the chemicals from the moisture and the soil reach the pipe, it becomes corroded. This corrosive reaction is known as "pipe line bugs." These "bugs" work as far as the moisture follows the pipe, leaving it with rusty pits or grooves. Sometimes they may run in a straight line down the pipe or they may attack it in its whole circumference.

Corrosion is sometimes the result of one of two kinds of electrolysis, electrochemical (galvanic action) and stray electric current. The predominating factors involving electrochemical electrolysis are soil with high moisture content and two dissimilar (or sometimes similar) metals coming in contact with one another. This is usually distinguished from other types of corrosion by the clean shiny pipe surface in the corroded area which will darken and oxidize rapidly on exposure to the atmosphere. This condition may be corrected either by removing the line to a new location or by doping the pipe, wrapping with a tar base paper and doping over the paper, thus insulating the pipe.

Electrolysis from stray electric current causes pits each time the current leaves the line. A pipe line is an excellent conductor of electricity. However, flanges with gaskets between them or other connections on the line may act as resistors to the flow of current. Some soils conduct electric current easily so the current leaves the pipe, following the line of least resistance, taking a piece of metal with it. Electric current does not harm the pipe as it enters but only as it leaves. The action of this phenomenon is irregular in leaving the pipe inasmuch as the resistance encountered may vary in the locality in which this electrolytic corrosion is found. Where the least resistance is found, the area affected is smaller but the pits are larger and deeper than where the resistance is greater causing a larger area of pipe to be pitted. To prevent recurrence of electrolytic corrosion by stray electric current, 2-in. pipe is laid from the pipe line to a pit filled with scrap iron several hundred feet away. One end of the 2-in. pipe is welded to the pipe line and the other end is laid into the scrap iron pit. Finally the small line and scrap iron are buried, affording a ground in which to dissipate the current to prevent its return to the pipe line.

To repair the damage done by the "bugs" or by electrolytic corrosion, excavation is made around the pipe until good pipe is found. The deteriorated section is cleaned, spot welded with the electric arc, re-doped, and fresh dirt is hauled in to refill the ditch.

When the deterioration is found on one section of the pipe and running in a straight line, the pipe looks as though a gouge had been run along its surface, running off its course at times and taking a deeper bite in a few

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* Scheduled for the Twenty-Sixth Annual Meeting, A.W.S., October 1945.

† Welder, Texas-New Mexico Pipe Line Co.

places. When this condition is found, a half sole is used to cover the affected portion of the pipe. A piece of equal diameter pipe is split longitudinally, then clamped tightly to the line and welded along the edges and the ends. The pipe is cleaned and re-doped in the ditch, leaving no chance to break the dope in handling the pipe. Where the half-soling method is used and fresh dirt is hauled in to fill the ditch the corrosive reaction seldom continues.

Another method of combating corrosion in alkaline formations or when salt water accumulates is to excavate the pipe and clean it. H-frames are then constructed and set in the ground across which the line is laid above the ground. Usually the pipe is cut out of the line at each end enabling the welder to do all recondition welding in a flat position. The reclaimed pipe is then welded back into the line and re-doped.

In New Mexico oil fields, few roads have been constructed. Usually they are made by driving from the nearest point on a road to the place you wish to reach. When traffic demands become great enough, a road is built, usually crossing a pipe line. This requires lowering and casing the line to a safe depth through the right-of-way. The ditch is deepened and if it is possible to discontinue the use of the line for a short time, it is cut at one end and a pipe of larger diameter is slipped over it. The line is then welded back and a vent is installed at each end of the casing outside the right-of-way after which the ends of the casing are sealed. If a leak occurs inside the casing, the oil is forced out through the vents and is easily seen from the road by passers-by. If, due to the amount of oil being run, it is impossible to take the line out of service, the casing is cut in half longitudinally and the pieces are then placed around the pipe and welded together. All oil companies require the casing of oil pipe lines through a camp site.

Running scrapers to clean the lines is one of the most important jobs in combating interior corrosion in a pipe line. A scraper consists of one or more rubber disks, metal brushes, metal rowels. The disks force sediment and water in the pipe ahead of the scraper. The brushes clean the pipe walls of scale and paraffin. The brushes are usually placed between the two disks or ahead of the disk if there is only one. The rowels or rollers are on arms which are shoved out against the pipe wall by springs. These arms serve as a guide for the scraper and as it moves through the pipe the line walker can hear it, enabling him to know its location at all times. He follows it from the time it is put into the line in the sending trap, a by-pass constructed and welded into the line to form a pocket, until it reaches the receiving trap, a by-pass similar to the sending trap.

Sometimes a scraper gets stuck in the pipe. If it is not possible to force it through with a pump and another scraper, the line is cut and the scrapers and obstruction are removed, and the line is welded again. The reason for running the second scraper when one is already in the line is to determine the exact location of the first scraper, since it may change position before the repair crew can get there.

If, due to the amount of oil being moved, it is not possible to take a line out of service while a lodged scraper is being removed, connections are welded to the line on either side of the scraper. Gate valves are placed on the connections and the line is tapped with a tapping machine. A by-pass is thus constructed around the clogged portion of the line and service is resumed without loss of oil.

During the present labor shortage, maintenance is a very important task. Lack of maintaining gathering lines or main lines leads to unexpected repairs. Repair jobs interrupt a construction or maintenance job that might be under way. A spot of welding in time and at the right place would save oil, labor and expense, but since it is impossible to foresee these emergencies, sometimes a pipe line needs repairs.

Holes in pipe are responsible for the majority of the repairs that we make. These are caused by interior or exterior corrosion, or both. Interior corrosion can hardly be found by inspection so must become a repair before it is known to exist. A stream of oil comes bubbling out of the ground and starts running over a rancher's grass land, or in some sandy country where it is almost impossible to use ordinary transportation, or it may break by a road that is frequently or infrequently used. It is possible that the leak may be found soon after the oil appears. If it is not found soon, oil run reports show a shortage and investigation will be made. The line walker or rider may find the trouble.

The repair of a leak is practically the same regardless of where it occurs. The pipe must be excavated, the leak found, and the oil stopped by some temporary method such as wooden plugs until a permanent repair can be effected. After the oil is stopped, and the excavation is completed, the pipe is cleaned and inspected to determine the type of clamp to be used. There are several types of repair clamps designed for welded repair. However, I have found it more practical to take a piece of pipe and construct a clamp to suit the repair to be made because sometimes the pipe is deformed. After the clamp is secured to the pipe, a safety zone is established in the area of the repair to be made by cleaning the bell hole and covering the oil with fresh dirt. Then the clamp is welded to the pipe.

Occasionally a hole is burned in the pipe during welding operations. If the line is full of oil, the oil will spray out causing a fire. If the welder will run the rod into the hole, it will shut off most of the oil and the fire watchers can extinguish the burning oil with sand or dirt. Then the extra repair can be made by belling one end of a section of pipe so that it fits snugly against and over the end of the patch that is being welded on. The welder places a small gasket in this patch to cover the hole, clamps it with a U-bolt and proceeds with the repair. The use of welding clamps or patches is standard as they leave the inside of the pipe free from obstruction.

Following the repair of a leak, disposal must be made of oil that has not soaked into the ground to prevent livestock from drinking it. If a leak occurs on grass land and the grass is dry, it must be covered with fresh dirt to prevent a grass fire. Where material damage to property is not involved the oil is burned. Otherwise it is completely covered with soil. Damages are paid to the property owner because it will be many years before vegetation will grow in oil-saturated soil.

Gravity lines are laid in a graded ditch. Sometimes it is impossible to keep sags out of the line and in these low places water and sediment collect inside the pipe. This is the beginning of a leak caused by interior corrosion. The leak is repaired and soon another hole may come a short distance from the first. When this has occurred several times, the line is excavated and levels are taken on this section of the line. The pipe is cut at its high points, removed from the ditch and cleaned, after which it is thoroughly inspected for holes. If any are found they are repaired. The pipe is then turned one-half over, the original top now the bottom, and welded back into the line. Levels are taken again. This section is graded to give it the same degree of fall as the rest of the line. This type of repair is possible because a gravity line fully loaded has a very low pressure. Water cannot settle in the pits inside the pipe which are now on top, and the oil will act as a retarding agent to the corrosive action. There is not enough

pressure to rupture the pipe in its weakest point on the top, so in reality you have the equivalent of a new line and the expenditure is only labor, whereas if new pipe were laid, cost of the new pipe and the welding of the new section would be involved.

Lines laid with screw-end pipe become loose in the couplings or perhaps a thread breaks off. When this occurs on the gathering lines the coupling is welded at each end, eliminating one joint; if it occurs on the main lines carrying a high pressure, a patented collar sleeve is used. This sleeve is made of two pieces of pipe of larger diameter than the line to be repaired, and swaged on each end to fit the pipe, long enough to extend across the coupling. The lower piece of this sleeve is drilled and tapped and a piece of $^3/_4$-in. pipe is inserted enabling the welder to run the leaking oil away from the immediate vicinity of welding operations. After the sleeve is welded the $^3/_4$ in. pipe is replaced by a threaded plug which is welded to effect a completely welded repair.

After screw-end pipe is removed from its present service it is beveled and used again in an all-welded line.

Safety is most important in our work. Fire is the greatest hazard, and every precaution is taken to prevent it. During welding operations clean soil is sprinkled on the small fires that may start from oil seepage in the bell-hole. Dirt is used to extinguish fires caused from burning through an oil-loaded line unless it gets out of control, then CO_2 type extinguishers are used. The welder is the only man allowed in the bell-hole during the welding operations. We always use pipe cutters to make the initial cut on a closed line. Then if other cutting or welding is to be done, each end of the line is packed with mud. However, if a section of pipe is to be removed, that section is left open.

We have found it safe procedure any time a line is cut to weld a connection on the upstream end of the pipe about 500 ft. from the place where welding operations are in progress. Then the line is tapped and a man is stationed at this connection. It is the duty of this man to report any undue amount of oil flowing down the line at this place. This makes it possible to take any safety precautions that may be necessary to protect the welder or other men working in the bell-hole.

During the past three years no member of the maintenance and repair crew in this district has suffered a time-lost accident.

Statement of the Ownership, Management, Circulation, etc.

REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933

OF THE WELDING JOURNAL, published monthly at Easton, Pa., for October 1, 1944.

State of New York } ss.
County of New York }

Before me, a Notary Public in and for the State and County aforesaid, personally appeared William Spraragen, who, having been duly sworn according to law, deposes and says that he is the Editor of THE WELDING JOURNAL and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

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WILLIAM SPRARAGEN, Editor.

Sworn to and subscribed before me this 27th day of September, 1945. (Seal) MARY T. HICKEY
Notary Public, New York County Clerk's No. 122.
New York County Register's No. 365-H-6.
(My commission expires March 30, 1946.)

War-Proved Advances in Low-Reactance Cable*

By Myron Zucker†

MANY war-time "gun-welder" jobs have made such severe demands on welding cables that the pace of improvements in cable has been rapid. This condition applies especially to low-reactance water-cooled cables, which were drafted into the munitions program even though they were not altogether physically fit. The technical details by which the interleaved type of cable has been brought from a prewar semi-experimental accessory up to the present stage of commercial product, are of interest to the welding industry as a basis upon which to judge its peacetime value. Some of the test methods by which various features were compared and improved may also be useful to engineers in selecting cables for particular applications.

We will consider changes that affect cable flexibility, weight, life, rating and other characteristics of the interleaved type low-reactance gun-welder cable made by Mackworth G. Rees, Inc.

A. Flexibility.—Ease of bending and twisting is of prime importance to the welding operator. It may be measured by means of an "overhang" test (Fig. 1) and a twisting test (Fig. 2). Table 1 gives values for some key designs. (In all cases, higher numbers mean greater flexibility.) The current design of interleaved Kickless Cable compares favorably in flexibility with two ordinary conductors in their water-cooled hose coverings.

1. The main improvement in flexibility is credited to a better outer covering. After trial of several constructions for the hose, each of which had some drawback, the present three-layer hose was adopted: steam-hose stock inside, wear-resistant stock outside (naturally not as good as is anticipated when the rubber industry is less restricted), and a fabric reinforcement that is braided on the inner hose while still on the mandrel. The reinforcement is the key to the flexibility of the hose: it is essential that the threads be of the right size and braided around the inner layer of hose with the correct pitch, separation and tension. That the hose manufacturer has learned how to do this is shown by the satisfactory service the hose has given despite the admittedly poor rubber substitutes available. The greater strength of reinforcement allows a thinner section of rubber to be used, and this also adds to the flexibility.

2. Use of larger water-outlet openings has contributed somewhat to increased flexibility, because of lower water pressure in the hose. Although this is not a major factor with the type hose now used in Kickless Cable, the effect of water-insert size is given in Table 2 for the light it may throw on other cases.

* Scheduled for Twenty-Sixth Annual Meeting, A.W.S., October, 1945.
† Mackworth G. Rees, Inc., Detroit, Mich.

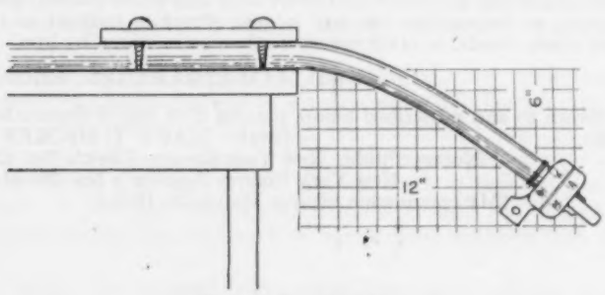

Fig. 1—Bending Test

The deflection from horizontal is measured as the cable end hangs free. For comparison between cables, the terminals must be the same.

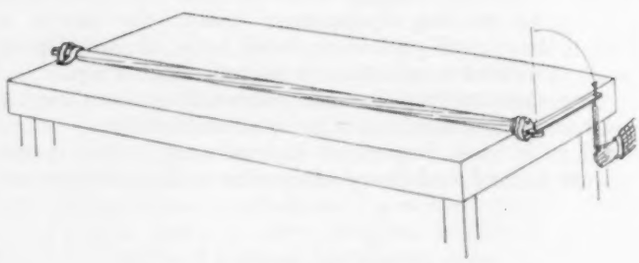

Fig. 2—Twist Test

The force is applied one foot from the axis of the cable and the cable is twisted 90°.

Table 1—Cable Flexibility

Flexibility of Light-Duty (267 Mcm) Rees Interleaved Cable 30 Psi. Water Pressure; 6-Ft. Inlet Hose 1/4-In. I.D.

	Stage		
	Prewar	Early War	1945
Bending:			
Inches deflection in 1-ft. overhang. Type 2-21 terminals (2.5 lb.)			
No water	3.8	3.5	7.5
Normal water flow	...	...	7.2
Cable outlet plugged	...	...	6.3
Twisting			
Degrees twist per foot-pound of twisting force			
6-Ft. Cable:			
No water	33	...	53
Normal water flow	31	...	45
Cable outlet plugged	15	...	22
8-Ft. Cable:			
No water	45*	40*	65
Normal water flow	36*	30*	43
Cable outlet plugged	15*	24*	25

*Average of clockwise and counterclockwise values. On these cables, there was usually about 50% more flexibility in one direction than in the other. In modern cables, clockwise and counterclockwise values are practically the same.

Table 2A—Effect of Water Insert Size on Water Rate and Pressure in Cable

Supply Water Pressure: 30 Psi.
Water Hose to Cable: 10 Ft. of 1/4-In. I.D. Hose
Cable: 10-Ft. Light-Duty Kickless Cable with Regulating Gasket
Water Hose from Cable (Where Used): 10 Ft. of 1/4-In. I.D. Hose

	Water Outlet Size								
	1/8-In. I.D. Insert			1/4-In. I.D. Insert			No Insert (1/4-In. I.P.S. Opening)		
	Water Rate	Water Pressure Inside Cap Inlet	Outlet	Water Rate	Water Pressure Inside Cap Inlet	Outlet	Water Rate	Water Pressure Inside Cap Inlet	Outlet
Inlet Size:									
1/8-In. I.D. Insert									
No hose on outlet	1.5 Gpm.	10 Psi.	8 Psi.	1.75 Gpm.	3 Psi.	1 Psi.	1.7 Gpm.	2 Psi.	0.3 Psi.
With hose	1.2	17	15	1.7	5	3	...	..	...
1/4-In. I.D. Insert									
No hose on outlet	...	..	..	3.7	10	4	4.0	6	1.3
With hose	1.6	28	25	3.1	15	10	...	..	...

3. In early cables, flexibility decreased radically with age as the rubber separator and core "grew" under the influence of hot water. Since one of the essentials to the flexibility of interleaved cable is the ability of each conductor rope to move fairly independently in its own compartment (Fig. 3) the tight packing that resulted from swollen rubber ruined the flexibility after usage. This has been remedied by selection of stable synthetic separator and core material, so that now the cable remains flexible throughout its life.

The current design of cable, with these points added to the natural flexibility of the spiralled, interleaved design, has been accepted by some users as more flexible than the two ordinary cables they have replaced.

B. Weight.—1. Weight has been lowered slightly by use of the better hose, since—as mentioned above—thinner walls are used. In early years of the war, heavy-duty hose weighed 0.9 lb. per foot; now it weighs 0.67 lb. per foot.

2. When weight is the dominating point, it can sometimes be minimized by use of the smallest possible cable. Prewar cable life was so short and rating uncertain enough so that on heavy jobs it was necessary to use cables of generous size. Now, with proved application charts available, it is sometimes possible to decrease weight—and incidentally increase flexibility—by selecting a smaller size cable. (This must not be overdone, since it is at the sacrifice of both life and electrical efficiency.)

For example, suppose we want the lightest possible 8-ft. cable for a gun that welds two sheets of 14-gage clean low-carbon steel at the steady rate of 30 spots per minute. Is a light duty (267 Mcm) cable adequate?

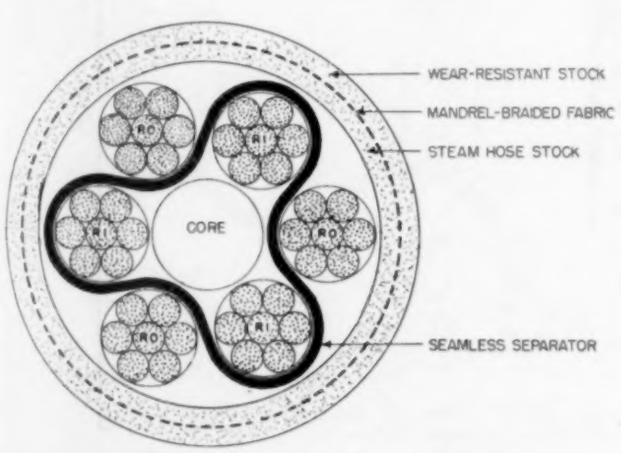

Fig. 3—Cross Section of Interleaved Type Cable

Table 2B—Comparison of Water Rate and Pressure in Prewar and Current Kickless Cable

Supply Water Pressure: 30 Psi.
Water Hose to Cable: 3 Ft. of 3/8-In. I.D.
Cable: 6-Ft. Light-Duty Kickless Cable
No Hose on Outlet

	Prewar	1945, with Regulating Gasket and New Design of Water Inserts		
I.D. of inlet insert	0.125	0.125	0.191	0.25
I.D. of outlet insert	0.125	0.125	0.250	0.25
Rate of water flow—gallons per minute				
Inner wires	0.7	1.5	2.1	2.6
Outer wires	2.5	1.4	1.9	2.4
Total	3.2	2.9	4.0	4.0

Facts upon which to base a decision are the current and time to be used in making the weld. For this example, we will take from Table 3 (a condensation of the A.W.S. suggestions which appeared as Table 8, page 314-s in the July 1944 WELDING JOURNAL) a current of 14,000 amp. applied for 17 cycles.

First consider the selection of cable size from the viewpoint of heating. The duty cycle factor corresponding to 17 cycles "on" time, 30 spots per minute continuously, is $(17 \times 30)/3600 = 0.142$. (3600 appears here because it is the number of cycles per minute in 60 cycle power.) Compare this required duty factor of 0.142 with the permissible factor of 0.18 obtained from Fig. 4, for a light duty cable 8 ft. long, carrying 14,000 amp.

In this case, the light-duty cable, if properly supplied with water, will not overheat. Advantage may be taken of its lightness and flexibility even on this apparently heavy job.

This may involve an increase in transformer size—for, as Fig. 4 shows, an 8-ft. light-duty cable takes 10 volts and the heavy duty only 6.5 volts to pass 14,000 amp. Assuming that the transformer secondary voltage equals cable volts plus 5 volts to send 14,000 amp. through weld, tool and transformer, we see that a transformer secondary of 11.5 volts would be sufficient if heavy-duty cable were used, whereas 15 volts will be needed to produce 14,000 amp. if the light-duty cable is installed.

If lightness and flexibility are paramount and ample transformer capacity is on hand, it is perfectly "legal" to use the lighter cable.

C. Life.—No representative figures can be given for cable life, since war production has prevented large-scale tests sufficiently well controlled to give accurate results

Table 3

Excerpt from Tentative A.W.S. Emergency Standard for Spot Welding Low-Carbon Steel. Published as Table 8 on page 314-s of "Mechanical Characteristics of Resistance Welds in Plain Carbon Steel," by W. Spraragen and M. A. Cordovi, THE WELDING JOURNAL, July 1944. (Tentative standard also includes electrode size and shape, minimum weld strength and electrode force, diameter of fused zone, weld spacing, and overlap.)

Thickness of Thinnest Outside Piece "T" In.	Gage	Weld Time, Single Impulse (60 per Sec.)	Approx. Current, Amp.
0.010	32	4	4,000
0.020	26	6	6,500
0.030	22	8	8,000
0.040	20	10	9,500
0.050	18	12	10,500
0.060	16	14	12,000
0.080	14	17	14,000
0.094	13	20	15,500
0.109	12	23	17,500
0.125	11	26	19,000

that take into account the variables of construction and usage. A few examples, however, indicate the improvement with respect to ordinary cables and early-war interleaved cables (Table 4).

1. Perhaps the greatest factor in lengthening the life of Kickless Cable is the choice of seamless neoprene tube instead of the cemented separator formerly used. Before this, a large percentage of failures were at the edge of the cemented overlap: removal of this weak point has effected noticeable increase in cable life.

2. Employment of nonswelling synthetic separator and core has improved life. The swelling of old cables previously discussed under "Flexibility" frequently got so bad that water circulation was practically stopped, and cable burned out. This has not occurred since synthetics have been adopted: an example of where synthetics are better than natural products.

3. Another important point is increased water flow obtained by a redesign of water inlet and outlet. About

Table 4—Cable Life

Cable life is measured here according to cable-months per cable failure. That is, if 50 guns are operating for six months and there are 30 cable failures during that time, cable life is $50 \times 6/30 = 10$ months. This method of stating cable life is crude, since it does not account—among other things—for the number of shifts worked per day, the severity of the job as determined by current and rate of welding, degree of bending or cooling conditions. It is, however, as accurate as the method of recording justifies; and if comparisons are made of cable on the same job, the figure does fulfill its purpose of showing the advance in cable life over a period of time.

Job	Life Ratio*	Principal Cause of Failure—Early War	Present
Steel truck frame	6†	(Shredding copper)	Separator
Assembly of military vehicles	2.8	Overheating inner wires	Operators neglect to turn on water
Railroad car panels	10.0	Failure at terminals	Separator
Reinforcing bus frames	3.5	Overheating inner wires; breakdown cemented separator	Wear outer hose
Light military vehicle bodies	10.7	Overheating inner wires; breakdown cemented separator	Wear outer hose
Farm equipment	3.0	Choking from swelling	Separator

* Ratio of present life to life of cable on same job in early years of war.

† Compared with ordinary single cables.

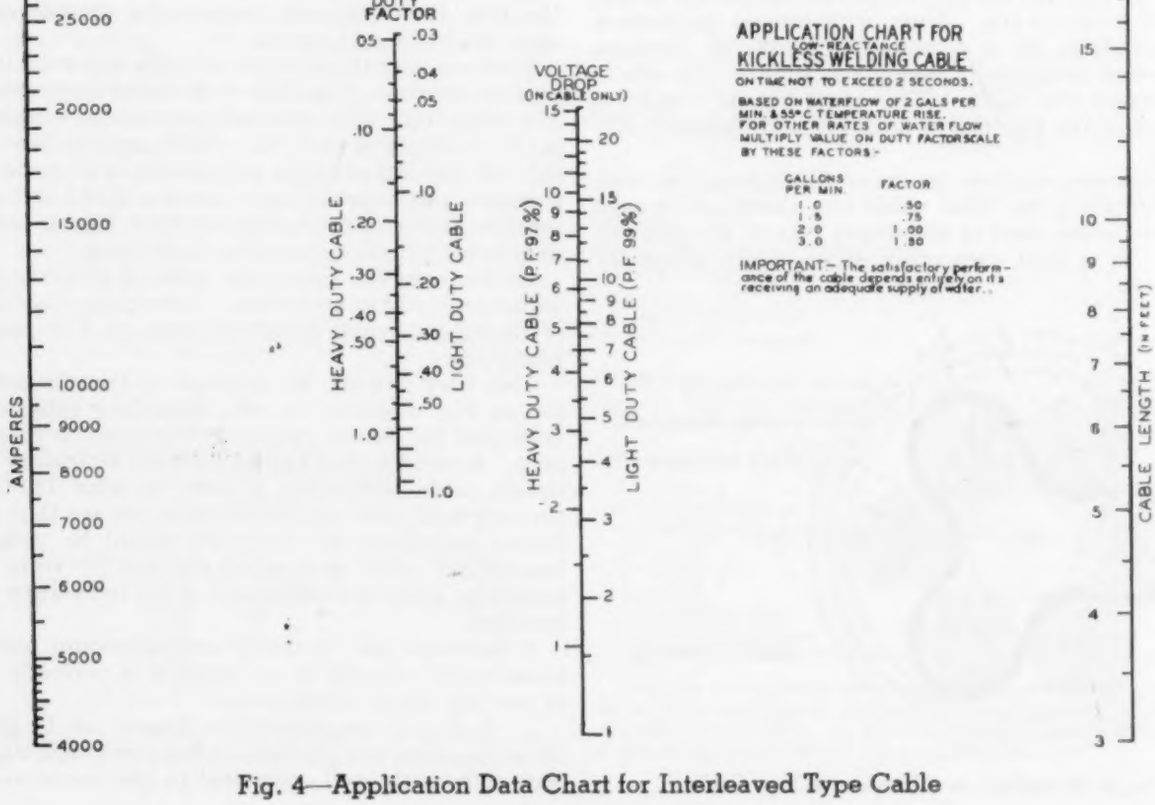

Fig. 4—Application Data Chart for Interleaved Type Cable

80% of the water pressure is absorbed at these points rather than in the length of the cable. Smoothing and slightly enlarging the paths results in greater water flow. (This is easily measured by seeing how long it takes the outlet water to fill a 3-gal. pail or a quart bottle to which it is diverted. Table 2A shows the effect of size inserts and 2B compares the old design with new cables and fittings of various sizes.) The hose fittings are furnished as standard parts of the cable and users are advised to check rate of water flow periodically to make sure they are running adequate water. This is a vital factor in maximum cable life and economy.

Many users of Kickless Cables have added still more to cable life by increasing the size of water-hose on their own initiative from the usual $^1/_4$ to $^3/_8$-in. I.D. At the same time, they are careful to install large fittings so as not to restrict water. Although ratings are based on 2 gpm., it is not uncommon to find 5 gpm. pouring through a light-duty cable in operation.

4. One practical detail that has radically increased cable life in some cases is a better understanding of methods of hanging the cable.

Users have realized that hanging low-reactance cable requires careful thought, not only to assure the operator a convenient position of the gun, but also to have a minimum of constrictions in the cable hose. It has been found that life is materially lengthened on all welding cables by supporting them only at the terminals. In those cases where the center must be suspended (as in Fig. 5) care is taken to keep the pull to a minimum and to provide a soft sling or shaped clamp around the hose. This minimizes local heating at the point of suspension.

Also, modern practice calls for running the cooling water "uphill." This is especially important on cables that have been looped as in Fig. 3, because this practice overcomes the tendency for air to become trapped at the high spot. Formation of air pockets is not permissible, since one reason for the success of this type of cable is the excellent cooling of all conductors by the water that contacts practically every strand. Air did become trapped and cables failed prematurely when water ran down the cables. The newer scheme of running water upward tends to carry away the air and restore normal water cooling.

Incidentally, this water circuit usually permits shorter drain hose, which decreases pressure in the cable (see Table 2A) with resulting slight advantage in flexibility and cable life.

5. Another detail of operation rather than design, is the method of changing welding electrodes. It has been found that many failures were caused by draining the cables of water when electrodes were changed, and then starting to weld before the cable became filled with water again. This is cured by either changing the points fast enough to prevent draining much water, or by allowing sufficient time after changing points for the water level to rise before beginning to weld.

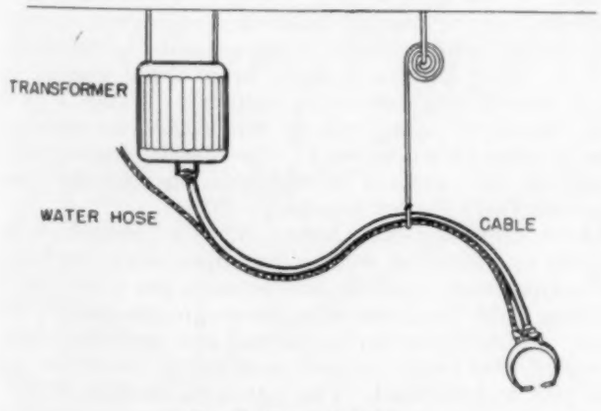

Fig. 5—Looped Cable

There are some applications in which the middle of the cable must be raised. In these cases it is especially important to run the cooling water "uphill."

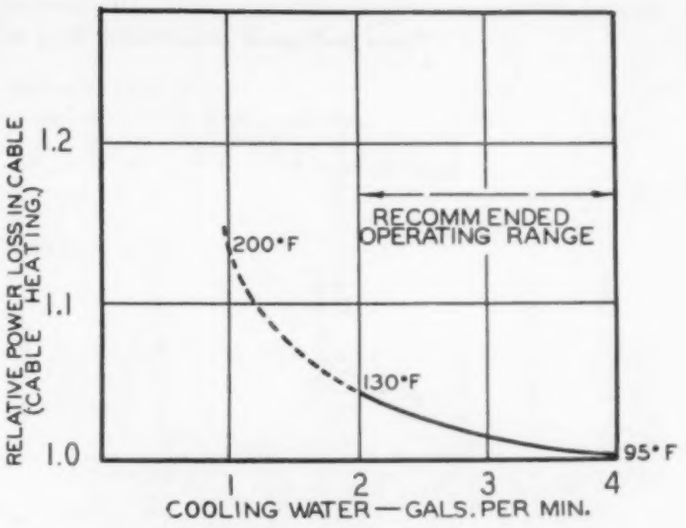

Fig. 6—Losses Depend on Water Flow

Decreased power loss from running more water through cable in a typical application. This principle applies to ordinary cable as well as the two types of low-reactance cables commercially available. The smaller losses not only lower the transformer tap and decrease the power bill, but, more important, they greatly increase cable life.

6. Returning to design, a point closely related to increased rate of water flow is better distribution of water within the cable. It was seen in "autopsies" of old-style cables that the wires inside the separator were frequently blacker than those outside. This indicated greater heating and consequent softening of the rubber. Tests with thermocouples showed this to be true, and established that the inner ropes needed 10% more water than the outer ones if they were to run at the same temperature. This relation is obtained by use of a regulating gasket that properly distributes the water (see Table 2B).

7. Use of a premium kind of copper, known as OFHC (oxygen-free high-conductivity) increases life. Years of experience have backed laboratory tests in demonstrating that such copper* has longer life than the electrolytic copper usually found in cables. Although the kickless nature of low-reactance cable removes the major cause of fatigue failure, the extra margin offered by OFHC against failure from the twisting and bending caused by gun manipulation is welcome. The bending stresses in interleaved cable are less than those in concentric, but still the increased cost of OFHC is justified, we believe, by the violent service anticipated especially in automotive construction.

8. Selection of wire-strand size to prevent "needling" has eliminated the plugging of water passages that plagues supervisors who use ordinary cable and some older-style low-reactance cables. Thus, one theoretical advantage of Kickless Cable has been brought to reality.

9. The better hose described before, capable of with-

* See bibliography in "Thermal Rating of Overhead Line Wire," *Transactions A.I.E.E.*, **62**, 501–507 (July 1943).

Table 5—Typical Gun-Welder Jobs with Light-Duty and Heavy-Duty Cables

Metal			Welding Procedure					Duty Factor* Applied			Permissible Cable		
Size Kickless Cable	Thickness (inches)	Gage Steel	Weld "On" Time: Cycles of 60-Cycle Power	Total Cycles per Weld	Number of Spots per Group	Active Time per Group—Seconds	Number of Groups per Hour	Factor for Each Weld	Factor for a Group	Complete Factor	Permissible Duty Factor on Cable for Given Length and Current	Length in Feet	Current in Amperes
Light Duty		18–18	12	360		Continuous		0.06	1.00	0.06	0.55	3	14,000
		18–18	6	30		Continuous		0.20	1.00	0.20	0.60	5	10,000
		18–20	4	20	50	16.7	60	0.20	0.68	0.14	0.18	8	14,000
		18–20	12	72	50	60	20	0.17	0.95	0.16	0.48	6	10,000
		20–20	12	20	24	12	75	0.60	0.57	0.34	0.45	8	9,000
		22–22	8	15	32	80	12	0.53	1.0	0.53	0.55	8	8,000
Heavy Duty													
	0.143	10	6 × 6 = 36†	6 × 12 = 72†	15	18	20	0.5	0.72	0.36	0.49	3.5	17,000‡
	0.143	10	9 × 6 = 54†	9 × 12 = 108†	15	27	20	0.5	0.84	0.42	0.49	3.5	17,000‡
	0.125	11	20	40	10	5.0	72	0.67	0.24	0.16	0.32	4	19,000‡
	0.094	13	9	17	80	23	6	0.53	0.8	0.41	0.41	5	15,000
	0.125	11	6 × 4 = 24†	36	10	6.0	60	0.67	0.34	0.22	0.28	5	18,000
	0.060	16	14	20	..	...	..	0.70	0.24	0.16	0.32	10	12,000

* Duty factor is similar to the "duty cycle" commonly used to measure severity of the work. The chief difference is that whereas "duty cycle" is simply the ratio of "on" time to total time, the "duty factor" takes account of the fact that welds are usually made in groups. (See "Rating of Electric Equipment Under Intermittent Load," *Transactions A.I.E.E.*, Vol. 63, November 1944. A discussion of a simpler method of applying this principle to welding is in preparation.)

There is sometimes a great difference between what a cable will carry under steady welding, and its rating when the welding is done in groups. For instance, in the third example under Heavy-Duty cables, "duty cycle" computed in the usual manner is 0.063—much less than the duty factor. In other cases, the difference may be in the opposite direction.

† In pulsation welding, the duty factor for a weld equals the "on" time for all impulses in one weld divided by the total time between welds.

‡ Cable has double water connection at inlet and outlet.

standing bending and high water pressure (even though pressure in the cable is normally quite low) increases cable life. Although the quality of outer rubber is not what could be desired at present, it has met wartime demands satisfactorily. It is anticipated that the severe abrasive service found in some civilian factories will be served by the present hose design, when tough rubber is again available.

10. Dependable connections of conductor to terminal are assured by improved manufacturing methods. They also eliminate trouble-making bits of solder that used to stray down the cable.

11. Oversize gaskets separating the terminal cap from the base prevent premature short-circuiting from dirt deposits.

D. Adaptability to all sizes, styles and makes of guns has been enhanced by a wide selection of terminals and adapters.

E. Electrical Resistance.—1. High-conductivity castings for terminals have decreased their resistance. Previous ordinary copper castings had about 30% conductivity, where the current ones have about 80%. In many cases this difference is unimportant, but the increased percentage of heavy-current jobs during the war made it imperative to decrease power loss in the terminals so they stay comfortably cool.

2. Resistance of conductors is lowered, indirectly, by the improved water supply mentioned before. Since copper resistance goes up 3.5% for each 10° F. increase in temperature, considerably less power is lost in a cool-running cable (see Fig. 6). Transformer taps can be set correspondingly lower to get the required welding current.

F. Consistency results from use of machine methods of making parts and assembling major components. Resulting economies of manufacture are sufficient to balance the increased cost of the advanced design.

G. Rating Data.—Commercial laboratory tests yielded information from which application charts of Fig. 4 were drawn. From these charts, the proper size cable for a given job may be selected in advance, taking into account both welding ability and welding capacity as defined by A.W.S. Such selections have been found correct by many actual applications in industry. Table 5 gives some details of operations in which the two standard sizes of cable have been used. The margin of safety is indicated by the excess of "Permissible Duty Factor" over "Applied Duty Factor (complete)."

These improvements, tested in war production by welding operators as well as by supervisors, engineers and management, may be said to mark the transition of Kickless Cable from the experimental to the commercial stage. Applications during the last few years have been so varied that nearly every imaginable condition has been met and satisfied. The future production of commercial goods may, however, re-direct the emphasis on some qualities. The cable manufacturer is interested to see what changes may still be called for to yield maximum life and economy.

Economics of Arc Welding*

By Walter J. Brooking†

THE GREAT extent to which the arc-welding method of producing machines and structures in modern manufacturing is an indication that it has certain inherent advantages both from an engineering and from an economic standpoint which cause its wide acceptance. The great growth in the amount of welded products during the past years naturally has, to some degree, displaced older methods of manufacture.

In many cases the advantages of welding have caused units to be fabricated rather than made of cast iron, where often from 20 to 40% saving in weight and in some cases special mechanical engineering advantages may be obtained.

In other cases welding has displaced bolted or riveted construction where frequently an 8 to 15% saving in weight has been accomplished because welding joins edges; whereas riveting or bolting fastens members of joints which have been lapped over one another, and often reinforced with side plates with an attendant bulkiness of material considerably greater than the joined edges in the welded construction. Greater rigidity and superior mechanical function frequently are characteristics found in arc-welded construction as compared to bolted or riveted construction which cause the choice of the welded method.

Arc welding of steel structural materials has made it possible to produce machines the operational efficiency of which is directly attributable to characteristics of design which cannot be economically obtained by any other means of making the machine. The high-speed tractor and earthmoving machine shown in Fig. 1 is an example of such a machine.

Much has been said and much reliable information is available upon the flexibility, the economy and the over-

Fig. 1—This Earthmoving Scraper and High-Speed Tractor Owe Their Superiority Largely to the Difference Between Arc-Welded Design and Other Ways of Producing Machinery

all practical aspects of the use of arc welding in modern manufacture. The case for or against arc welding as a means of manufacturing economically has already been well described in general terms, supplemented by the use of many specific examples, so it will not be reviewed in this paper.

The purpose of this discussion is pointedly to present the relationships of several important factors common to all welding applications which greatly affect the total cost of the welded structure. These factors variously and collectively influence the total cost, and therefore the economics, of welded structures depending upon the amount of control exercised on these various factors.*

This paper deals with only eight of the many factors effecting the economics of welded construction; these eight being considered especially important and all of them so general that they are universal problems in welded construction.

* Scheduled for Twenty-Sixth Annual Meeting, A.W.S., October 1945.

† Director of Testing & Research, R. G. LeTourneau, Inc., Peoria, Ill.

* A more complete coverage of how to control these factors can be found in a recent book by the author published by McGraw-Hill Book Company entitled "Are Welding Engineering and Production Control."

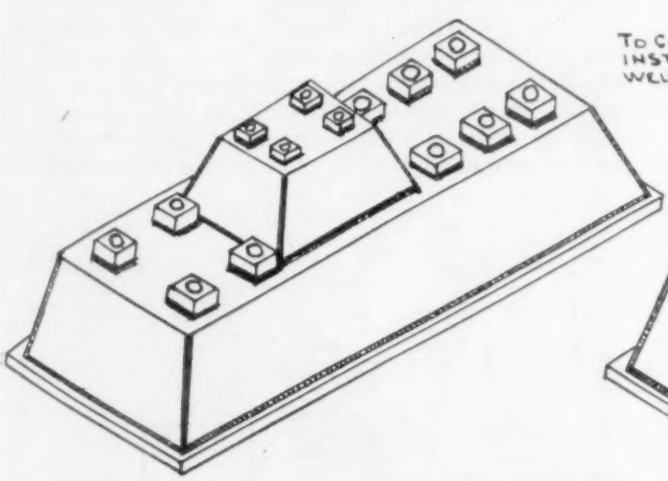

Fig. 2—This Arc-Welded Machine Base Has Been Chosen as a Representative Welded Structure for the Purpose of This Discussion. This View Represents a Base Made According to the "Normally Attainable Good Practice" Herein Discussed

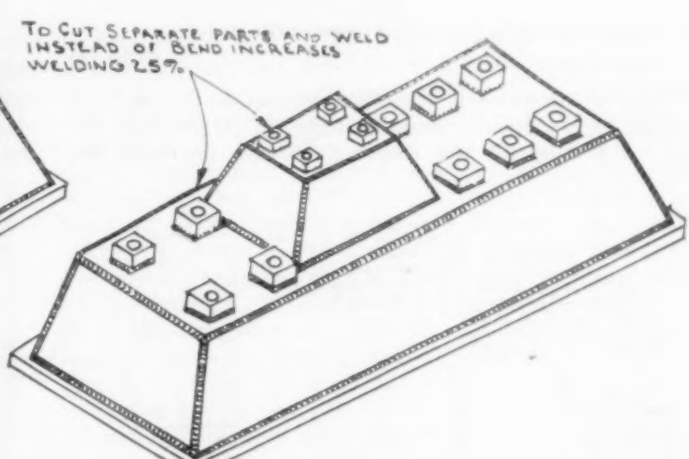

Fig. 3—The Same Machine Base as Shown in Fig. 2, But There Are 25% More Inches of Welding on It Due to the Joints Which Were Cut and Welded on This Base Instead of Bent, as Shown in Fig. 2

They are as follows:

1. Design to reduce the amount of weld metal required in the structures.
2. Plan the use of material to reduce scrap.
3. Use setting up fixtures to eliminate measuring and to standardize structures.
4. Use positioning fixtures to deposit welds in most favorable positions.
5. Use the most economical size of electrode.
6. Obtain good fit-up of welded joints.
7. Control the size of welded joints to their proper size.
8. Obtain a good operator factor (use of workman's time).

Method of Illustration and Organization Used for This Discussion

This is a generalized discussion of universal factors and in order to provide a sound basis for demonstrating the importance of each of the foregoing factors, an hypothetical welded structure, the simple welded machine base shown in Fig. 2, has been selected.

It is assumed that this machine base is made of arc-welded steel in any ordinary welding shop, and that it would be made on a mass production basis to make the manufacture of them a repetitive process like many repetitive manufacturing processes in present-day welding production. This would assume at least 100 units to be made.

To establish a fundamental basis of comparison, a cost of production of this machine base had been established assuming normally obtainable good welding practice in their manufacture.

With good practice, the bases are assumed to cost $100 each, based upon the following conditions, assumptions and values.

The finished weight of the base is 1000 lb., consisting of 950 lb. of steel and 50 lb. of weld metal.

1000 lb of steel at 4¢ per pound, allowing 5% scrap loss	$40.00
1.64 hr. setting up time at $1.10 per hour, plus 150% overhead, (2.75 an hour)	4.50
5 hours' cutting, shaping machining and forming time at $1 per average, plus 150% overhead ($2.50 per hour)	12.50
50 lb. of deposited weld metal at 86¢ per pound	43.00
Total cost with normally obtainable good practice	$100.00

This cost assumes a 70% continuous work, such as arc time and electrode changing time, $1.10 per hour for labor for setting up and welding, 66⅔% electrode deposition efficiency, electrode cost of 6¢ per pound, the calculation of overhead at 150% of the labor, and the use of electrodes averaging ¼ in. in diameter.

In the interests of clarity and relative simplicity of making pointed illustrations which show the value of each of the factors discussed in detail, several small and relatively minor factors have been disregarded and some cost factors have been combined for simplicity.

An example is the combining of the cost of welding electrodes into the cost of deposited weld metal and using the cost of deposited weld metal per pound as a basis for calculating welding costs. The reason for including welding electrodes in the per pound cost of deposited weld metal is that for most of the factors which are fundamentally associated with the deposition of weld metal, any increase in welding results in an increase in electrode consumption and material cost.

Electrode costs themselves are a small percentage of the total cost of the entire structure. However, this method of expressing electrode welding cost gives a slight expansion of total cost because of the assigning of 150% overhead against the electrode cost as well as the welding labor. This is a relatively small percentage in the diagrammatic illustration of the machine base example selected for this discussion.

The basis for calculation in the discussion in each of the following paragraphs is given, and in all cases where a theoretical approach has been made the basis for the calculation, a stop watch analysis of shop operation has been found to compare very favorably with the results established by the theoretical approach.

A detailed discussion of each of the eight factors follows:

1. *Design to Reduce Welding and Deposited Weld Metal*

As soon as an organization has committed itself to produce a certain type of structure or equipment by arc welding, a careful analysis of the design of the unit to reduce the amount of necessary welding often yields important economic advantages. *Fundamentally, weld metal is expensive; and all other factors being equal, the welded design with the least weld metal is the best.*

In the case of the machine base postulated in Fig. 2, assuming good welding practice, the side plates and top plate of the main base as well as the side plates and top plate of the smaller secondary box-like base, are made by notching the corners of two appropriately cut plates and bending the sides down so that the only welding required is the welding up of the corners.

In Fig. 3 is shown a different method of making the same structures which requires more cutting and increases the welding 25% over the design in Fig. 2. Here the side plates and top plates are all cut from separate plates by shearing or flame cutting and are set together in the final setup and welded. This makes welded joints on

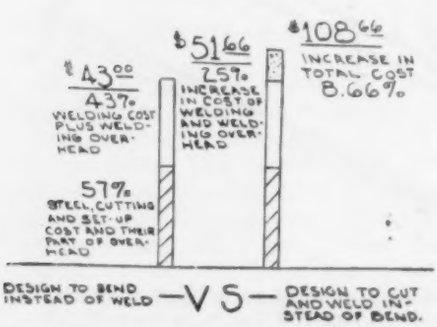

Fig. 4

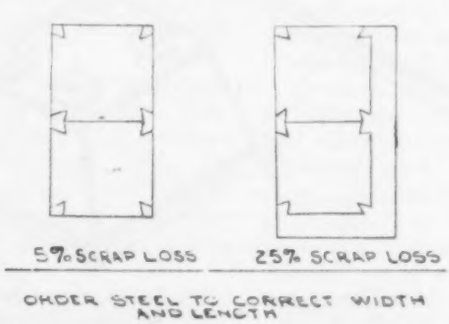

Fig. 5

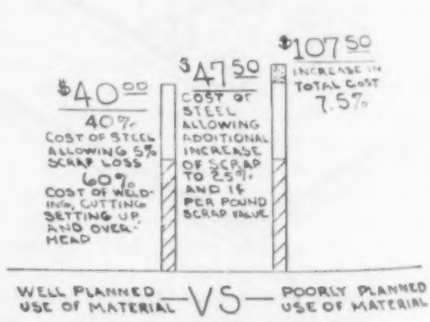
$40.00
40%
COST OF STEEL ALLOWING 5% SCRAP LOSS
60%
COST OF WELDING, CUTTING, SETTING UP AND OVERHEAD
$47.50
COST OF STEEL ALLOWING ADDITIONAL INCREASE OF SCRAP TO 25% AND 1¢ PER POUND SCRAP VALUE
$107.50
INCREASE IN TOTAL COST 7.5%
WELL PLANNED USE OF MATERIAL
VS
POORLY PLANNED USE OF MATERIAL

Fig. 6

the top corners of both the main base box and the smaller upper box instead of bent corners.

The relative cost of the normally good practice method shown in Fig. 2 compared to the design using more welding and less bending, is shown in the graph in Fig. 4.

According to the normally good practice shown in Fig. 2, the total cost of producing the unit is $100; of which welding cost, including labor, materials and overhead, amounted to $43 or 43% of the total cost.

In the design shown in Fig. 3, using several pieces and welding them together instead of bending, the welding was increased 25%. This represents a total increase in the cost of the finished unit of 8.66%. It also increased the number of parts in the individual structures from 17 to 25 and the finished weight from 1000 to 1012½ lb.

Not included in this enlarged cost is the increase in handling and the increase in set-up time using the less economical practice but it is assumed that this increase in handling and set-up time is offset by the higher overhead cost resulting from bending equipment and fixtures used in normally good practice for a mass production quantity of such units.

In this case, the largest saving is the result of the reduction of weld metal where 8.66% of the total cost is a significant margin compared to the normal net profit of manufacturing organizations.

2. Plan to Utilize Material to Best Advantage

Fundamentally, steel, as purchased for arc-welding manufacture, is a relatively inexpensive material. The planning to use it economically, however, provides a worth-while margin of economy since in many cases of welded construction, parts are taken from sheets, bar, strips or plates, and because of their odd shape, cause the scrapping of moderately high percentages of the purchased material.

To illustrate this point, the normally good practice assumed for the machine base in this discussion uses 1000 lb. of raw steel and by carefully planned consumption produces only 5% scrap or 50 lb. as illustrated by the cutting of two main parts as shown on the left in Fig. 5.

Figure 5 also illustrates a somewhat less carefully planned use of material where the same two parts are cut from standard 1250-lb. sheets instead of 1000-lb. sheets. On this general basis of efficiency an additional 250 lb. of steel are charged to each machine base. Allowing 1¢ per pound scrap value to the additional scrap used there still is a total increase of $7.50 to the total cost of the unit or a 7½% increase in the total cost.

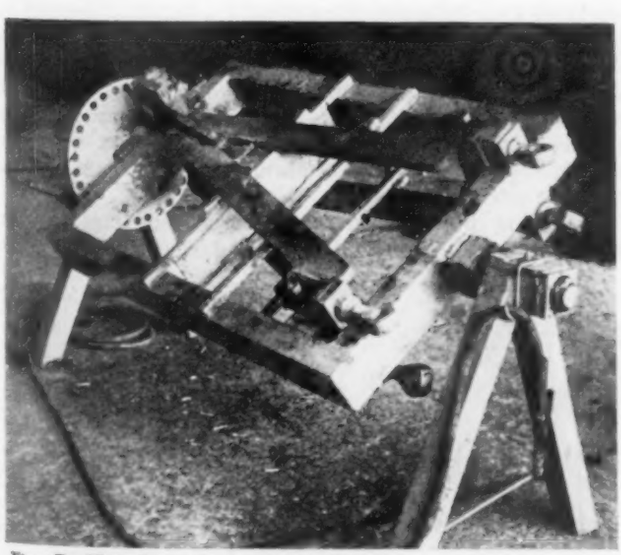

Fig. 7—This Is a Combination Setting up and Positioning (Spinner Type) Fixture. The Stops, Clamps, Pins and Machined Surface Guards Reduce Measuring and Setting Up Time to a Small Fraction of What It Would Be Without Such a Fixture

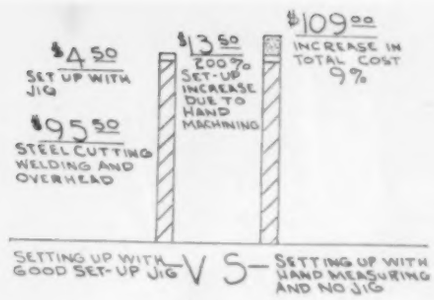
$4 50
SET UP WITH JIG
$9 50
STEEL CUTTING WELDING AND OVERHEAD
$13 50
200% SET-UP INCREASE DUE TO HAND MACHINING
$109 00
INCREASE IN TOTAL COST 9%
SETTING UP WITH GOOD SET-UP JIG
V S
SETTING UP WITH HAND MEASURING AND NO JIG

Fig. 8

In general arc-welding manufacture, square or regularly shaped oblong parts, such as shown in Fig. 2, normally should be produced with a relatively small percentage of scrap. However, in the case of circular or irregular shaped, 25, 30 and even up to 50% scrap is not unusual nor is it uneconomical in many cases, but it is a source of additional cost, some of which may be eliminated by careful planning.

Figure 6 shows the relationship of the increase of the steel scrap to 25% of the raw material instead of 5% of the raw material as described above and demonstrates it to be a significant figure. It would provide a margin of $750 on 100 of these machine bases.

3. Quick Setting Up Fixtures to Eliminate Hand Measuring

Any method of mass production which is sound must produce a standardized finished product. One of the most important contributors to standardized arc-welded products is a fixture for setting up the component parts of the structures prior to welding.

This setting up operation must be accurately done, yet it may be done with a widely varying amount of measuring and careful operator attention with widely varying resultant setting up costs.

Good welding practice dictates that for a repetitive operation, there should be setting up fixtures which allow an operator to place the component parts of a structure in the fixture without error, and in their proper relationship. This should be done with a very minimum of measuring of individual parts and careful positioning.

A fixture such as the one shown in Fig. 7 provides stops, a framework upon which to place the parts; and plugs, guards and clamps which accommodate premachined parts and all other parts in their proper relationship. It reduces setting up time to a bare minimum and provides maximum standardization of the structures set up in it.

Stop watch studies of setting up operations with and without fixtures, indicate differences of several hundred per cent in setting up without a fixture compared to setting up with a good fixture. This is mostly due to the additional measuring and fastening time required without a fixture. Assuming a very conservative 200% difference and assuming the setting up time for these machine bases in good practice to amount to only $4.50, Fig. 8 indicates the total cost of setting up without a fixture as $13.50 or a total of a 9% increase in the overall cost. This represents a $900 margin on 100 of these machine bases and it represents a good margin with which to build a simple set-up jig and still realize a profit.

4. Using Positioning Fixtures for Depositing of Welds

Because weld metal is a liquid at the time it is de-

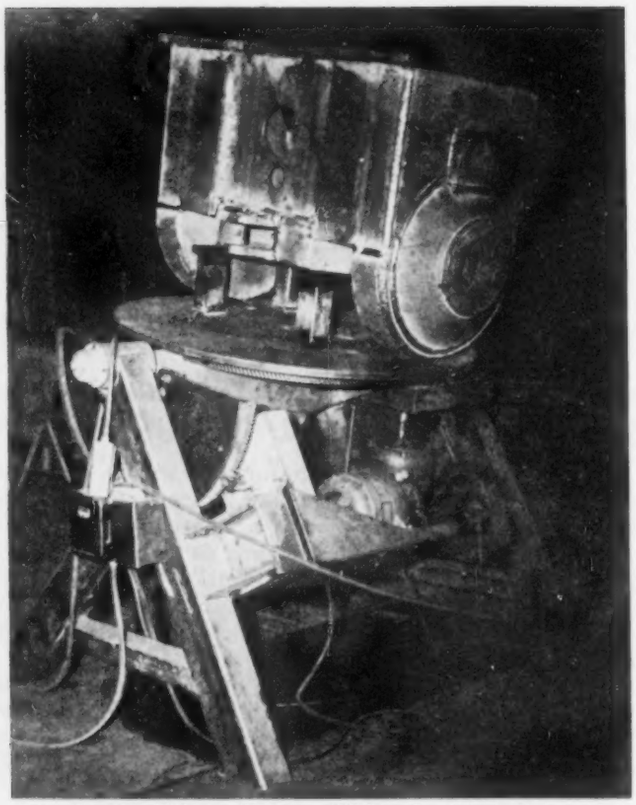

Fig. 9—Jigs Which Position Welds for Most Economical Deposition Pay Dividends on Mass Production Jobs. This Is an All-Welded, Power-Driven, Universal Positioner

posited, the position of the joint at the time in which a weld is deposited automatically establishes certain limitations on the size of the electrode and the amount of the molten metal which can be deposited within a given time on a joint. Ordinarily the nearer completely down-hand (into a trough-like joint) position into which a weld may be placed for deposition, the less difficulty is encountered due to the fluidity of the metal; and within certain limits, the larger is the welding electrode which may be used. This is especially true of heavier plates and applies to even the relatively light plates used in this machine base.

There are many types of jigs or positioning fixtures for providing means of placing welds in their best position for welding. Figure 9 shows a power-driven mechanical positioning fixture similar to the rather standardized and commercially available types of fixtures. The use of such a fixture would be applicable to a machine base such as the one selected for this discussion. It provides universal positioning of all welds, and in the case of this machine base would provide a good advantage. It would also be useable for other welding jobs in an ordinary welding production shop.

Figure 10 illustrates in graphic form the relative cost of depositing $^3/_8$-in. welds in the different positions—vertical, horizontal fillet and the completely down-hand fillet position.

The basis for the figures in this graph are numerous time studies of actual weld deposition time under normal shop conditions, using arc time, electrode changing time, and adding an appropriate allowance for operator fatigue (20% of total time).

The normally good operating conditions under which this machine base was welded assumed down-hand position welding, using a fixture such as shown in Fig. 9, or some similar fixture providing down-hand welding. If this unit were not positioned in a fixture, additional handling time to block it up and thereby position it or the additional time required to deposit the welds in the horizontal fillet position and the corner welds in the vertical position would increase the cost considerably.

Conservatively interpreting the values shown in Fig. 10, the unpositioned welding of this unit would increase the cost of welding 50% (since the normally good practice figure represents a $33^1/_2$% reduction of the unpositioned and therefore poorer practice). The result of not positioning the welds in this case would represent an increase in cost of $21.50 for welding, or $21^1/_2$% increase in the total cost of the structure.

In depositing the welds in the vertical or horizontal fillet position under ideal practice, it would not necessarily mean that a larger amount of weld metal would be deposited, but under ordinary welding operating conditions, a larger amount of weld metal would usually be deposited because of the tendency for the lower leg of a weld deposited in the horizontal fillet position to be longer than the upper leg. This produces a degree of overwelding if the upper leg is made the specified size.

The increase of $21^1/_2$% in the total cost as diagrammatically shown in Fig. 11, represents a very considerable margin for operation, yet based on actual time studies and numerous examples throughout the welding industry as a whole, it is a margin which is not overstated in this case, but rather conservatively stated.

5. *Using the Most Economical Size of Electrode*

The amount of weld metal deposited by a given size of electrode depends more upon the volume of metal in the wire in the electrode than upon any other factor.

Stop watch studies of the burning off of welding electrodes of different sizes from $^1/_8$ in. in diameter to $^5/_{16}$ in. in diameter and all of the same length indicate that with the machine setting correct for the burning of that electrode on an average job, each takes about the same length of time. This time varies somewhat, but usually it requires about 90 sec. when a 14-in. electrode is burned down to a stub of about $1^1/_2$ in. with a normal machine setting.

Assuming this value to be the correct length of time for burning an electrode and assuming that the length of

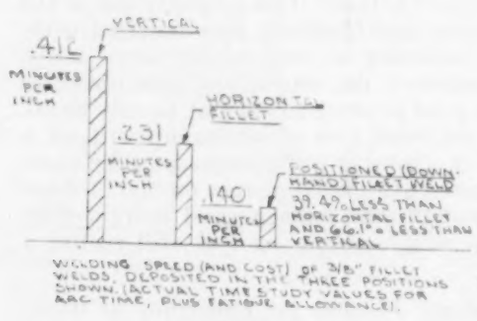
.416
VERTICAL
MINUTES PER INCH
.231
HORIZONTAL FILLET
MINUTES PER INCH
.140
POSITIONED (DOWN-HAND) FILLET WELD
39.4% LESS THAN HORIZONTAL FILLET AND 66.1% LESS THAN VERTICAL
MINUTES PER INCH
WELDING SPEED (AND COST) OF 3/8" FILLET WELDS, DEPOSITED IN THE THREE POSITIONS SHOWN. (ACTUAL TIME STUDY VALUES FOR ARC TIME, PLUS FATIGUE ALLOWANCE).

Fig. 10

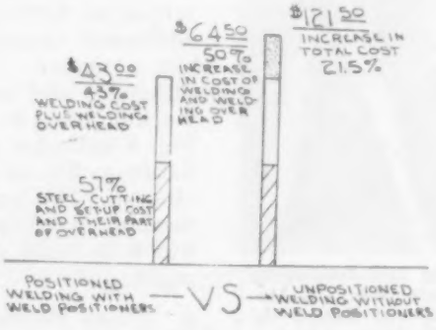

Fig. 11

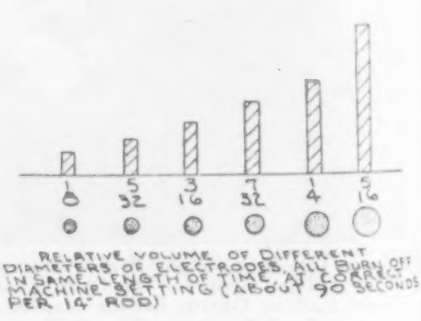
1/8
5/32
3/16
7/32
1/4
5/16
RELATIVE VOLUME OF DIFFERENT DIAMETERS OF ELECTRODES, ALL BURN OFF IN SAME LENGTH OF TIME, AT CORRECT MACHINE SETTING (ABOUT 90 SECONDS PER 14" ROD)

Fig. 12

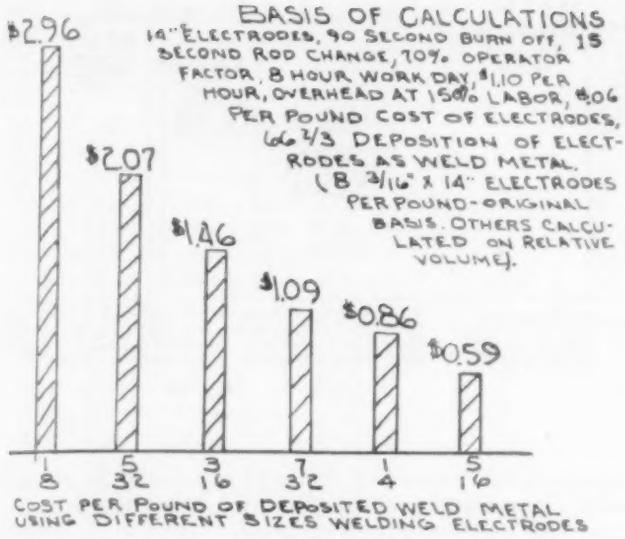
BASIS OF CALCULATIONS
14" ELECTRODES, 90 SECOND BURN OFF, 15 SECOND ROD CHANGE, 70% OPERATOR FACTOR, 8 HOUR WORK DAY, $1.10 PER HOUR, OVERHEAD AT 150% LABOR, $.06 PER POUND COST OF ELECTRODES, 66 2/3 DEPOSITION OF ELECTRODES AS WELD METAL. (B 3/16" X 14" ELECTRODES PER POUND - ORIGINAL BASIS. OTHERS CALCULATED ON RELATIVE VOLUME).
$2.96
$2.07
$1.46
$1.09
$0.86
$0.59
1/8
5/32
3/16
7/32
1/4
5/16
COST PER POUND OF DEPOSITED WELD METAL USING DIFFERENT SIZES WELDING ELECTRODES

Fig. 13

time for burning electrodes of different diameters is the same, then the amount of deposited weld metal for a given size of electrode depends upon the volume of the wire; and the length of time required to deposit a pound of weld metal with each given size of electrode has a definite relationship to the amount of wire deposited per electrode.

This relationship, assuming 90 sec. burnoff and 15 sec. for changing electrodes, forms the basis for the difference in cost per pound of deposited weld metal using different sizes of electrodes, assuming a constant cost per hour for labor.

Figure 12 shows the relative volume of metal in $^1/_8$-, $^5/_{32}$-, $^3/_{16}$-, $^7/_{32}$-, $^1/_4$-, $^5/_{16}$-in. electrodes, based on their cross-sectional area.

Assuming all 14-in. electrodes were being used, and assuming the number of electrodes per pound to be in direct ratio to the cross-sectional area of the different sized electrodes, then the cost of depositing of a pound of weld metal using different sized electrodes at $1.10 an hour for labor, plus 150% overhead and $66^2/_3$% deposit of the efficiency of the electrode, is shown in Fig. 13.

There are many times when smaller electrodes are used than could be used. Even in some cases where positioning fixtures permit the use of welding electrodes of any size suitable for a given weld, smaller electrodes are used than are necessarily in keeping with good welding practice.

Assuming in the case of the machine base discussed herein that an average of $^1/_4$-in. diameter electrodes would be the best size and that only the difference between the use of an average of $^7/_{32}$-in. diameter electrode, the difference in cost is a significant figure as shown in the graph in Fig. 14.

This relatively insignificant difference of $^1/_{32}$ in. in size in the average diameter of electrode used ($^1/_4$ in. instead of $^7/_{32}$ in.) represents a total difference of 27% in welding cost alone or $11^1/_2$% difference in the total cost of the unit. If the $^7/_{32}$-in. electrode is used instead of the $^1/_4$-in. electrode, the total cost of the unit is increased $11^1/_2$% which means $11.50 per unit in this case. This is a sizable margin arising from a relatively insignificant appearing factor.

6. *Good Fitup of Welded Joints Compared to Poor Fitup of Welded Joints*

One of the most important of all factors in ordinary welding practice is the degree of perfection of fitting together of the component members of the joints in the welded structure prior to welding.

The economic basis for this importance lies in the fact that deposited weld metal is an expensive commodity and that what appears to be a relatively small gap in a welded joint, when analyzed from its volume compared to the volume of a finished weld, is often surprisingly large. These gaps must be filled with weld metal according to good welding practice; and normally a welding operator will overweld a gapping joint to be sure that it will not fail, rather than produce a weld including the filled up gap, equivalent to the correct size of joint which had no unusual gap.

Figure 15 shows the volume of a weld such as might be found in this machine base compared to the volume of the same weld made with a gap in the joint equivalent to one-half the size of the weld, followed by the normal practice of the operator of applying an additional amount of weld metal to be sure that the weld is properly safe.

Approaching the economics of this problem from the volume of weld metal alone, comparison shows that a filled gap one-half the size of the weld, plus the additional amount placed by a conservative operator for safety, represents more than three times the amount of weld metal used in the joint when it has a normal amount of gap.

This assumption leads to a vast understatement of the cost of a poor fitting joint because in the filling process a much smaller welding electrode is required and a much longer time is required for cleaning after each successive welding pass and for cooling of the joint between passes than for a normal fitting joint. This greatly increases the time of deposition over what would normally be used with the regular size electrode for a normal joint.

Therefore, the assumption in the case of this machine base, that the fitup at the corners and around the edges

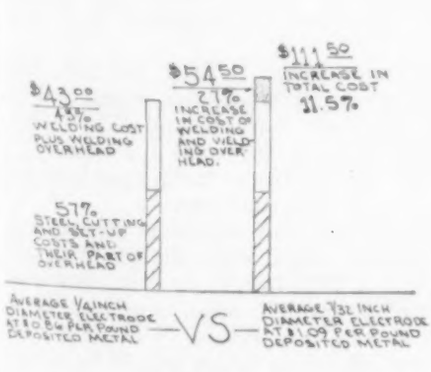
$43.00
43% WELDING COST PLUS WELDING OVERHEAD
57% STEEL CUTTING AND SET-UP COSTS AND THEIR PART OF OVERHEAD
$54.50
27% INCREASE IN COST OF WELDING AND WELDING OVERHEAD.
$111.50
INCREASE IN TOTAL COST 61.5%
AVERAGE 1/4 INCH DIAMETER ELECTRODE AT $.10 PER POUND DEPOSITED METAL
VS
AVERAGE 7/32 INCH DIAMETER ELECTRODE AT $.09 PER POUND DEPOSITED METAL

Fig. 14

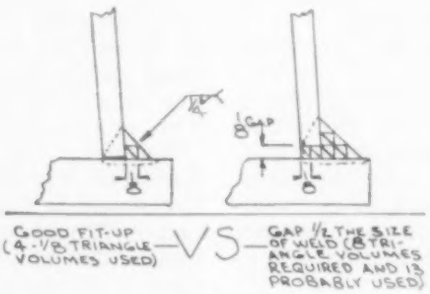

Fig. 15

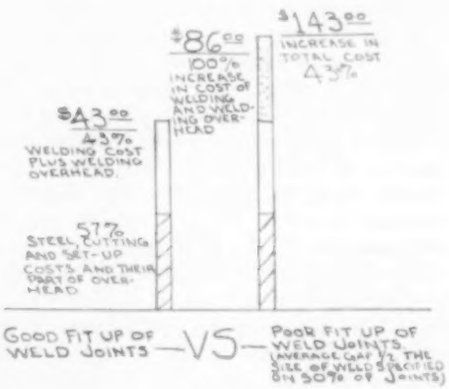
$43.00
43% WELDING COST PLUS WELDING OVERHEAD.
57% STEEL CUTTING AND SET-UP COSTS AND THEIR PART OF OVERHEAD
$86.00
100% INCREASE IN COST OF WELDING AND WELDING OVERHEAD
$143.00
INCREASE IN TOTAL COST 43%
GOOD FIT UP OF WELD JOINTS
VS
POOR FIT UP OF WELD JOINTS (AVERAGE GAP 1/2 THE SIZE OF WELD SPECIFIED ON 90% OF JOINTS)

Fig. 16

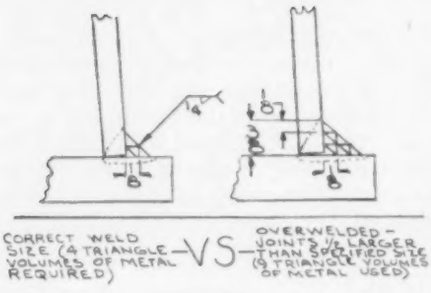
CORRECT WELD SIZE (4 TRIANGLE VOLUMES OF METAL REQUIRED)
VS
OVERWELDED - JOINTS ½ LARGER THAN SPECIFIED SIZE (9 TRIANGLE VOLUMES OF METAL USED)

Fig. 17

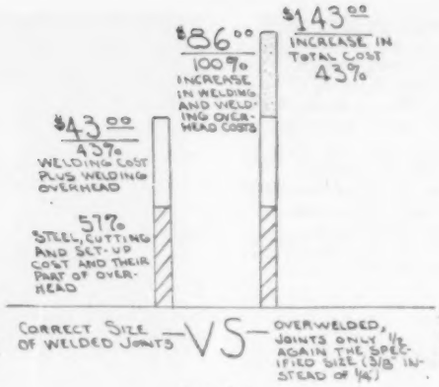

Fig. 18

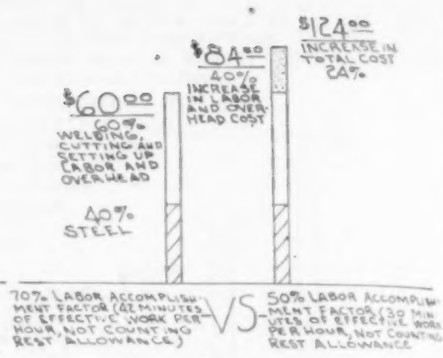
$60.00
60%
WELDING, CUTTING AND SETTING UP LABOR AND OVERHEAD
40%
STEEL
$84.00
40%
INCREASE IN LABOR AND OVERHEAD COST
$124.00
INCREASE IN TOTAL COST 24%
70% LABOR ACCOMPLISHMENT FACTOR (42 MINUTES OF EFFECTIVE WORK PER HOUR, NOT COUNTING REST ALLOWANCE)
VS
50% LABOR ACCOMPLISHMENT FACTOR (30 MINUTES OF EFFECTIVE WORK PER HOUR, NOT COUNTING REST ALLOWANCE)

Fig. 19

averages normally good for 50% of its length and has an average gap of $^1/_8$ of an inch (assuming $^1/_4$-in. sidewalls and a gap half the thickness of the size weld required in this particular case) increases the total volume of welds required for the job based on the above assumption by 100%. This represents a total of 43% increase in the total cost of the unit, as is graphically shown in Fig. 16.

In addition to the volumetric and related cost considerations, the structural strength and metallurgical quality of joints with gaps in them is inferior to joints with normally good fitup. Therefore, in a study of the economics of poor fitting joints, an undetermined amount of failure which is costly in good will or replacements of welded structures, must be considered. No attempt to evaluate that will be made in this discussion, but the very conservative figure established above may be checked by a stop watch time study of the process of filling up gaps and will usually be found to be conservative.

7. *Correct Size of Weld Compared to Overwelded Joints*

Another one of the most important economic factors in welded production is the control of the size of the welded joints so that the amount of weld metal is held down to the proper size rather than applied in excessive amounts.

If a fillet type weld is increased in size (and therefore in strength) to double its original leg measurement and strength, there is not just twice as much weld metal deposited, *instead there is four times as much deposited.* This relationship is shown in Fig. 17.

Overwelding is a very common practice and is very easily done, especially on structures which involve a large percentage of fillet type joints.

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It is assumed in this particular case that a $^1/_4$-in. weld size would be satisfactory for all of the welds in the structure, since all are box shaped or are blocks fastened all around to a $^1/_4$-in. thick wall section by welding.

For a comparison let us assume that the $^1/_4$-in. weld used in normally good practice were increased only 50% (from $^1/_4$ in. to $^3/_8$ in.). The result in welding cost is demonstrated in Fig. 18, which graphically shows that the increase of the dimensions of the weld by one-half, *more than doubled the amount of weld metal* deposited. Conservatively figured, it doubled the cost of the welding. This represents a 100% increase in the welding cost, or a 43% increase in the completed unit attributable to this factor alone—the cost of overwelding.

This is another factor where the theoretical value based on the volume of the weld can easily be checked with a stop watch and satisfactorily demonstrated. It is one of the most important economic factors in arc welding and is fundamentally the result of the fact that weld metal is expensive.

8. *Good Operator Factor (Workmanship Accomplishment) in Welding Manufacture*

A factor which exerts one of the most far-reaching effects upon the total cost of an arc-welded unit is that of operator factor on all of the direct labor operations. This is especially true of the arc-welding operation itself since the operation requires constant attention while the arc is burning and since the percentage of time which the arc is burning fundamentally controls the economy of the deposition of weld metal. If the arc is not burning, no weld metal is being deposited, no matter what the other conditions may be.

The same is true of cutting, bending, forming, machining, setting up and other direct labor operations, and the total effectiveness of the workman's use of his time on productive work greatly influences the total cost of the finished unit.

Fundamentally, the obtaining of a high percentage operating factor is based upon good planning; good layout of the shop; good organization of the tasks which must be done; good operation (mechanical condition) of fixtures, jigs, machines, etc.; combined with a good morale on the part of the workmen themselves. This latter element is probably more a combination of the former plus many other more or less intangible things, which constitute the motivation of the workmen themselves on their jobs. Sometimes an incentive system contributes tremendously to the effectiveness of workmanship (or operator factor).

Figure 19 shows an example of the relative importance of a good operator factor compared to one which is less desirable, namely, a 70% operator accomplishment (70% effective accomplishment by the workmen, not including the normal rest allowance) as compared to a 50% operating factor.

Seventy per cent may sound a little bit low, but assuming eight $^3/_{16}$ x 14-in. electrodes per pound and 24 lb. burned per day, at 90 sec. burnoff, and 15 sec. electrode change for each electrode, it results in a total of 42 min. of actual arc time and electrode changes per hour for 8 hr., or a total of 336 min. of actual work.

Because of the confining and attention demanding nature of depositing weld metal with the arc it is not uncommon to consider a 20% fatigue or rest allowance factor (12 min. out of 60) which, when computed on a basis of 336 min. in an 8-hr. day, results in an additional total of 83 min. of rest allowance which should be added to the 336 min. of work.

This amounts to a total of almost exactly 7 hr., leaving only 60 min. remaining in the day for handling time, job starting and stopping, cleaning up, changing jobs, getting electrodes; and adjusting the work, such as turning fixtures, preparing to weld, etc. This, therefore, represents a very good degree of operator accomplishment, although it is sometimes possible to achieve a higher one under most favorable circumstances.

A 50% operator factor which produces only 30 min. instead of 42 min. of work per hour (not including rest allowance) represents a 40% increase in the labor cost over the 70% operating factor on all direct labor. In the case of the machine base this 40% increase in labor costs causes a 24% increase in the total cost of the production of the unit.

This represents $2400 on a hundred of these machine bases as a margin for improvement between 50 and 70% operating factor. Since the over-all operator efficiency of a shop is one of the best indications of the degree of efficiency in the organization and the association of the workmen with the job, it is an extremely important factor. Some question might be raised about charging 150% overhead to a job with a poor operator factor; but the fact remains that if a poor operator factor is habitually the case in a shop, there are more workmen to do a given amount of work, which in turn requires more equipment, more payroll taxes, more factory space, more supervision and a general increase of the costs which contributes to overhead expense so that the relationship of the 50 to the 70% from the standpoint of overhead in all probability is about the same. Actually overhead expenses may possibly be greater for the 50% operator factor.

$322.80
ADDITIONAL COST OF 50% OPERATOR FACTOR APPLIED TO ALL ACCUMULATED LABOR IN LESS ECONOMICAL PRACTICE ($196.66 WORTH OF LABOR AT 70% OF OPERATOR FACTOR.) $76.66
$244.16
ADDITIONAL COST OF 50% OPERATOR FACTOR INSTEAD OF 70% BASED ON CORRECT PRACTICE THROUGHOUT 24.00
ADDITIONAL COST OF OVERWELDING USING 3/8 WELDS INSTEAD OF 1/4 WELDS 43.00
ADDITIONAL COST OF POOR FIT-UP 50% OF JOINTS WITH GAP EQUAL TO 1/2 SPECIFIED WELD SIZE. 43.00
AT 70% OPERATING FACTOR FOR ALL LABOR
ADDITIONAL COST USING 7/32" INSTEAD OF 1/4" ELECTRODES 11.50
ADDITIONAL COST OF WELDING WITHOUT POSITIONING FIXTURE 21.50
COST OF WELDING WITH GOOD PRACTICE 43.00
$100.00
WELDING-GOOD PRACTICE 43.00
SETTING UP WITH FIXTURE 4.50
CUTTING SHAPING FORMING 12.50
STEEL 40.00
(5% SCRAP LOSS)
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GOOD PRACTICE THROUGHOUT —VS— ACCUMULATED EFFECT OF LESS ECONOMICAL PRACTICE

Fig. 20

Summary of the Accumulated Affect of Each of the Eight Factors on Weld Cost

In the foregoing eight examples of the specific effect of a given factor on the cost of a welded unit only one at a time has been considered. This has been done to make the relative value of each factor specific and pointed.

It is important to show the cumulative effect on the total cost of all of the factors all of which were relatively conservative in themselves, and compare them to the original cost based on normally attainable good practice. Figure 20 shows the cumulative effect of all of the various factors in their proper relationship, based upon the assumption made with each factor in the section where it was described.

It should be borne in mind that each of these factors are added in Fig. 20 without any special interrelation of the effects of one upon the other. For example, the cost of the effect of overwelding is based on the assumption that $^1/_4$-in. electrodes were used in good practice and will also be used in the overwelding. If a smaller electrode should be used, say a $^7/_{32}$, which makes a difference of a total of $11^1/_2$% in the total cost of the unit, the cost of overwelding would be 27% greater than it actually was assumed to be. The same might be said of the consideration of the cost of welding up bad fits.

Even with this conservative approach, it is of considerable interest to observe that while assuming the almost ideal 70% operator factor, the total cost of the unit, with the accumulated cost effect of the less desirable practice (conservative though it may have been) amounts to $244.16. This is an increase of over 144%. It represents the difference between a cost of $10,000 for 100 machine bases, compared to $24,416 for the same 100 machine bases.

Should we assume a 50% operator factor instead of a 70% operator factor, the cost immediately goes to $322.80 or an increase of 222.8% above the cost of the normally attainable good practice, rated at 100%. Even if proper discount is made for the inclusion of elements which slightly expand overhead in some of these costs, the accumulated cost of making these bases with the less desirable practice exceeds 300% the cost with normally attainable good practice in arc-welding manufacture.

These differences when accumulated may look to be very large. In actual practice, careful study with stop watch and other accurate measuring devices indicate that they are of such great importance that they represent the largest common margin for economic improvement in arc welding.

New applications of arc welding in manufacturing seldom begin at the highest degree of obtainable good practice, yet often provide a very desirable margin of profit even at the start. The margin of additional profit or economic advantage obtainable by improving the various phases of the operation to the best practice attainable for that job adds much to the competitive position of the manufacturer.

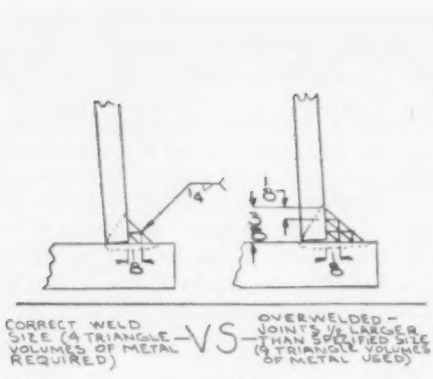
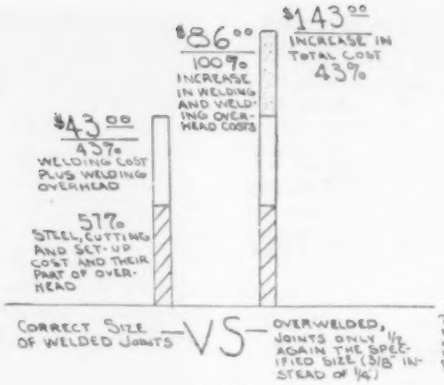

CORRECT WELD SIZE (4 TRIANGLE VOLUMES OF METAL REQUIRED)
-VS-
OVERWELDED - JOINTS 1/2 LARGER THAN SPECIFIED SIZE (9 TRIANGLE VOLUMES OF METAL USED)

Fig. 17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-VS-
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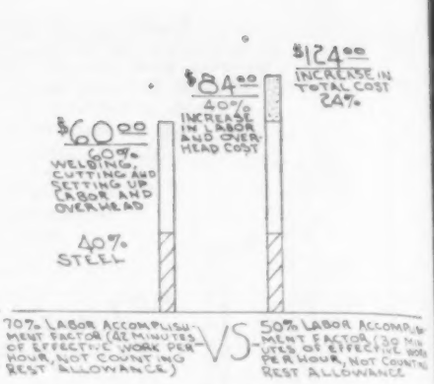
Fig. 18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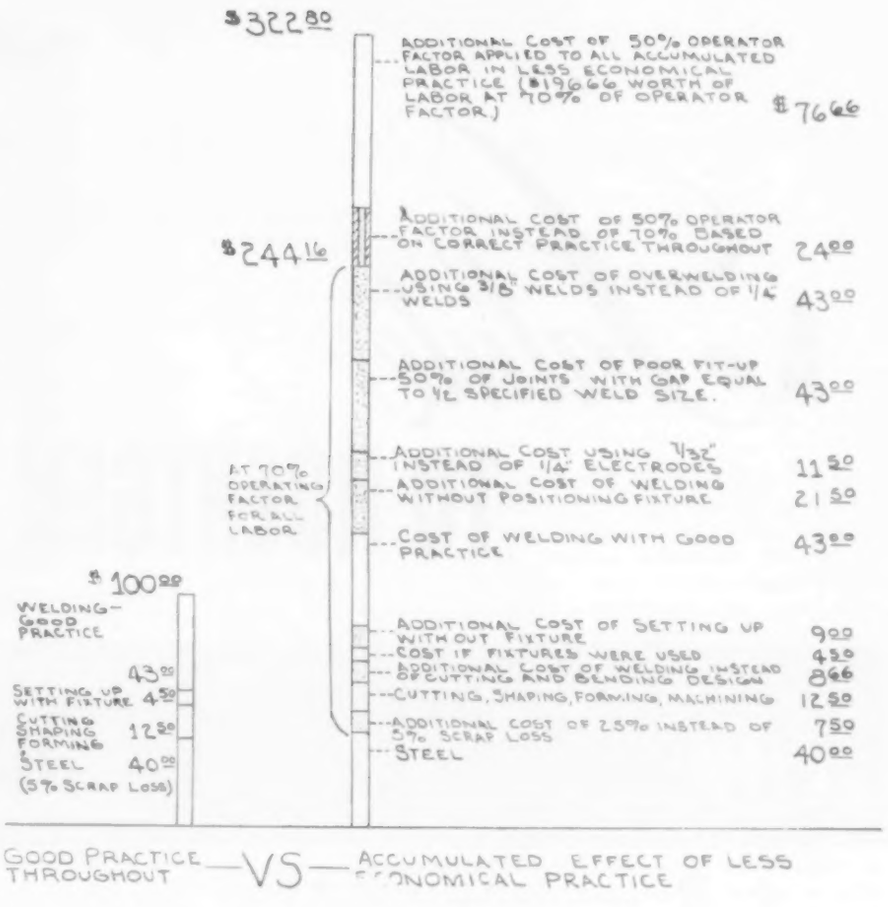
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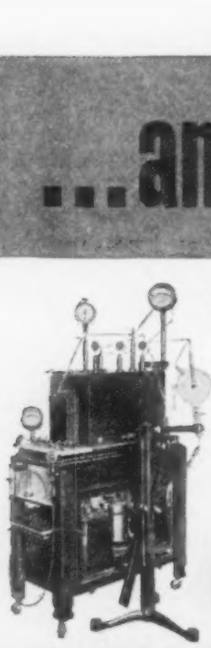
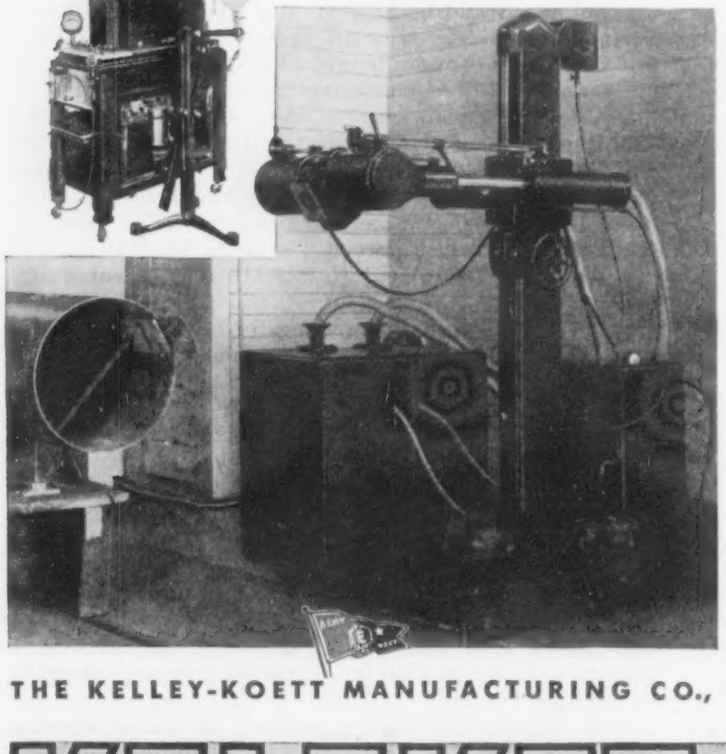
A *Salute* TO ROENTGEN

...and a PLEDGE for the FUTURE



As early as 1905 Keleket perfected this "Grosse Flamme" X-ray coil, so called because it "drew a flame of 12 inches" when other coils produced but a few inches of spark.

The New KELEKET 220 KV is a powerful industrial X-ray unit with plenty of power and penetration to cover a wide range of inspections.



IT is now 50 years since Wilhelm Konrad Roentgen discovered the X-ray. From this discovery came not only a great new instrument of medicine, but also a method of industrial inspection revealing flaws and imperfections not visible to the human eye.

But the X-ray of today is very different from the X-ray of Roentgen's period. Fifty years of improving—of refining—of perfecting—have gone into it.

KELEKET—oldest company continuously in X-ray, was in business within five years of Roentgen's discovery. KELEKET and X-ray grew up together. And now KELEKET leads the way in producing the industrial inspection equipment which so greatly accelerated the wartime output of the nation.

In saluting the achievement of Roentgen, KELEKET also pledges that just as KELEKET X-ray medical equipment has gone hand in hand with the progress of medical science, so KELEKET industrial X-ray equipment will keep pace with the technological developments of the industrial world.

THE KELLEY-KOETT MANUFACTURING CO., 21811 W. FOURTH ST., COVINGTON, KY.

KELEKET X-RAY

Application of Capacitor Discharge to Welding*

By H. J. Bichsel and J. R. Parsons†

Introduction

CAPACITOR discharge welding control has been applied in the past five years mainly in the industries engaged in the fabrication of aluminum. The use of such control was brought about primarily to meet the demand for a method of welding aluminum consistently in high-production assembly lines with low kva. demand and without frequent stoppage for electrode dressing and replacement. Aluminum and its alloys, such as 17S, 24S and 52S are difficult to weld by ordinary means because of their high electrical conductivity and their narrow plastic range. Metals with such characteristics require that the heat applied to the weld be precisely controlled if welds free from defects and of acceptable strength are to be made in large quantities.

The capacitor discharge system was developed with many features of a precision nature because it had to meet the difficult problems involved in welding aluminum. On the machines, for example, the use of the double pressure head was evolved when it was found necessary to "forge" the welds on the heavier materials. This also necessitated the use of lighter or low inertia heads on the welding machines so that the electrode movement could follow the deformation of the material and respond quickly to the forge pressure. At the same time it was found that the use of high pressures, and precision initiation of the weld discharge at the correct pressure resulted in more consistent welds. This necessitated the development of the present calibrated pressure heads—such as the spring and air bellows types—and micrometer adjusted initiating switches.

To keep in step with these refinements in welding machines, the controls must accurately regulate the capacitor energy regardless of line voltage variations. The sequencing circuits in the control must be designed to initiate the welding discharge when the proper welding pressure is reached. The sequence of machine operation also must be automatically controlled by the sequence circuits. A precision forge timer is included in the control to time the interval between the start of the weld discharge and the application of the forge pressure. It also supplies the energy for operating the forge valve very rapidly and consistently.

A welding system incorporating all of these refinements is necessarily very expensive. However its cost is quite easily justified for aluminum welding. With a decrease in the manufacture of aircraft, a decrease in aluminum welding may well be expected. It is, therefore, logical to ask what the future application of capacitor discharge equipment will be.

The present capacitor discharge equipment is capable of welding magnesium, stainless steel and mild steel besides aluminum. Since welding stainless steel and mild steel is not as critical as welding aluminum and magnesium the cost of the system may be considerably reduced for these applications. Some welding data will be given for these materials and the application of capacitor discharge systems for welding them will be discussed.

Description of System

Capacitor discharge control consists fundamentally of a thyratron tube rectifier (usually of the three-phase bridge type), a capacitor bank and an ignitron tube or contactor system for discharging the capacitor energy into the primary of the welding transformer. This system is shown in block form in Fig. 1. The rectifier acts as the source of d.-c. voltage to charge the capacitor bank. The capacitor voltage is regulated by controlling the grids of the rectifier tubes. When the capacitors are charged to the proper voltage and the electrodes on the welding machine have been brought together under pressure, the capacitors are discharged through the contactor or a tube system into the primary of the welding transformer and produce a weld in the material between the electrodes. The welding cycle is shown graphically in Fig. 2.

The capacitor discharge control accumulates energy for the weld in the capacitor bank. This capacitor bank then acts as an independent source of energy for the weld and instantaneous variations in supply line voltage, due to the operation of other welding machines or to the starting of motors, have no effect on the weld current. As additional protection from supply voltage variations no current is drawn from the line during the weld. This

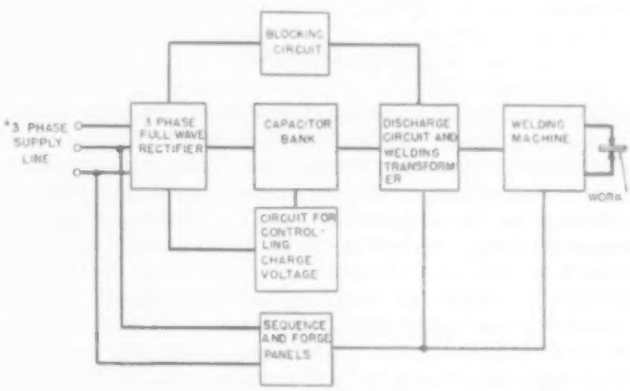


Fig. 1—Block Diagram Showing the Various Components of a Capacitor Discharge Control

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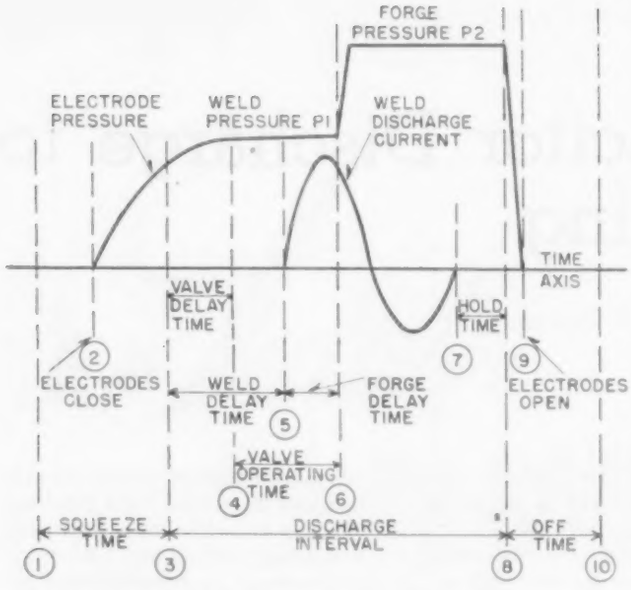

Fig. 2—Diagram of a Welding Cycle Showing Reference of the Pressure and Current Functions

allows the welding current to be completely independent of the supply source and results in highly consistent welds.

Capacitor discharge control provides adjustment of the following factors: (1) The amount of energy can be controlled very precisely by adjustment of the capacitor voltage, and by selection of the amount of capacitance. The capacitor voltage is the principal quantity in determining the capacitor energy as shown in the energy equation

$$W = {}^1/_2CE^2 \qquad (1)$$

where W is expressed as joules, C is the capacitance in microfarads and E is the voltage to which the capacitors are charged. It is evident that doubling the capacitor voltage provides four times the amount of energy to the weld. The equation shows that capacitance also affects the energy, but only to the first power. (2) The wave shape of the weld current can be adjusted by proper selection of capacitance, and by adjustment of the turn ratio of the welding transformer. The shape of the weld current wave determines the rate of heat transfer to the weld zone. Capacitance principally affects the time the current wave takes to reach its peak value. The greater the capacitance, the longer the time taken to reach peak current. The transformer turn ratio changes the initial slope or rate of rise of the discharge current. The higher the turn ratio, the less the slope of the wave becomes.

Kva. Demand

A comparison of line demand between an energy storage machine and a single-phase a.-c. welder is a difficult one to make unless two specific machines are compared. In general, the kva. demand of an energy storage system is related to the maximum number of operations per minute of which control is capable, on the thickest material to be welded. This speed of operation determines the time available for charging the capacitors. It also determines the maximum kva. demand of the control. The kva. demand, once determined, remains constant for all capacitance and voltage settings, and all operating speeds.

An a.-c. welding machine, on the other hand, operates on a variable kva. demand basis. Its demand is just that required to make the weld and is supplied only during the time the weld is taking place.

Most of the capacitor discharge controls built during the past few years are capable of making between 20 and 40 welds per minute on two pieces of 0.102-in. material. This allows approximately 1 sec. to charge the capacitors and results in a maximum three-phase demand of between 50 and 70 kva. An a.-c. welding machine, operating at 50% power factor would have a demand of approximately 300 kva. when welding two pieces of 0.102-in. aluminum. When welding the lighter gages the demand decreases until with 0.020-in. material the single-phase demand would be about the same as three-phase demand of the capacitor discharge control. This example represents present design practice for the majority of the energy storage machines and may be changed in the future if higher welding speeds are desired. Generally the capacitor discharge machine will effect a saving in demand charges over those of an a.-c. machine because the weld energy is taken from the line over a relatively long period of time compared to an a.-c. machine.

Forging

In welding aluminum alloys, it has been found that a rapid increase in electrode pressure a short time after the current discharge is started, eliminates cracks and voids in the weld. This process known as "forging" or "double pressure" is most effective when the forge pressure is 2 or 3 times the initial pressure and when the pressure change is completed in less than 0.016 sec. after starting. Application of the forge pressure must be timed to occur very shortly after the peak of the current wave. The timing is very critical and must be controlled accurately (within ±0.1 cycle) to produce the desired results. The weld "nugget" is freezing very rapidly when forge pressure is applied, so that too early an application results in deforming the weld, while too late an application acts on a solidified weld and has no benefit. Generally, the more pressure used in forging the less critical is the time of application of the pressure to produce crack-free welds. However, the pressure is limited by the amount of indentation allowed on the material and by the maximum pressure developed by the welding machine.

Types of Machines and Control

Three different sizes of machines and control are used generally. The smallest size, suitable for bench or wall mounting, is used for welding small wire (usually special alloys), very light gage sheet metal, and many of the small parts used in electronic tubes. The controls for the machines have a capacitance range of 20 to 60 μf. and a voltage range of 500 to 1500 v. The welding transformers have three or four taps and the turn ratios can be varied from 450:1 to 100:1 in 100 or 150 turn steps. The controls have no sequence, the weld discharge being initiated by a pressure switch on the head of the welding machine. The operator presses the foot lever to apply air pressure (or mechanical pressure through levers) to the electrodes to bring them together. When the pressure has been built up to the setting of the pressure switch, the capacitor bank is discharged through the transformer to make a weld. The machines are capable of between 50 and 100 operations per minute at maximum capacitance and voltage with about 7 kva. demand.

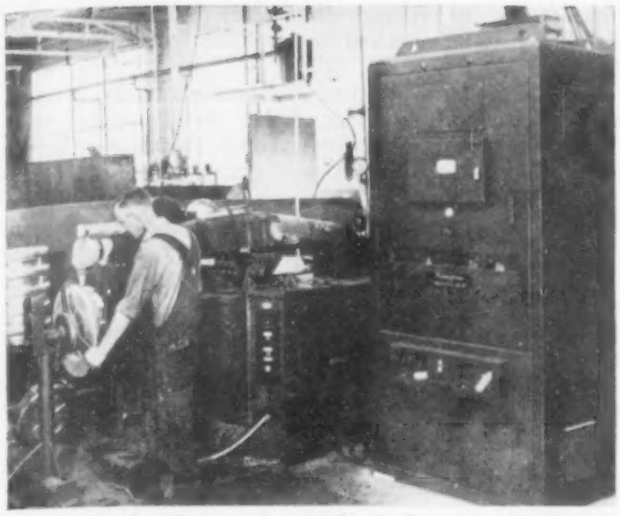

Fig. 3—An Installation of a 2640 μf. Capacitor Discharge Control and a Rocker Arm Machine

The second size of control is made to go with any of the three sizes of welding machines for welding materials below 0.102 in. It incorporates a maximum capacitance of 2640 μf. Heavier gages of material can be welded with this control by the addition of capacitors in auxiliary housings. An installation of a control and machine of this type is shown in Fig. 3.

These controls are equipped with a precison capacitor voltage control system that regulates the voltage to within ±2% of the preset value and stops the charging current without undershooting or overshooting this value. This control is capable of making 20 to 30 welds a minute continuously, on 2 pieces of 0.102-in. 24ST aluminum and will weld as fast as 200 times a minute on 0.020-in. 24ST aluminum. The capacitance is adjustable from 240 μf. to 2640 μf., in steps small enough to give a continuous range of energy. The control is provided with a sequence that times the electrode pressure build-up, the discharge interval, and the off time, and is arranged to give automatic repeat operation as long as the foot switch is held down. The rectifier is blocked (output reduced to zero) during the discharge but begins to charge the capacitors immediately after the discharge has stopped. The control is also provided with safety devices that remove the high voltage when the cabinet doors are opened. Another circuit prevents operation of the control if the capacitor voltage is too high.

The third and usually largest size of machine is the roll spot. This machine is a combination spot and seam welder whose electrodes consist of two copper alloy wheels rotating against each other. The material to be welded is fed between the wheels and current discharges are made at intervals while the wheels rotate. These discharges produce welds on the material at spaced intervals.

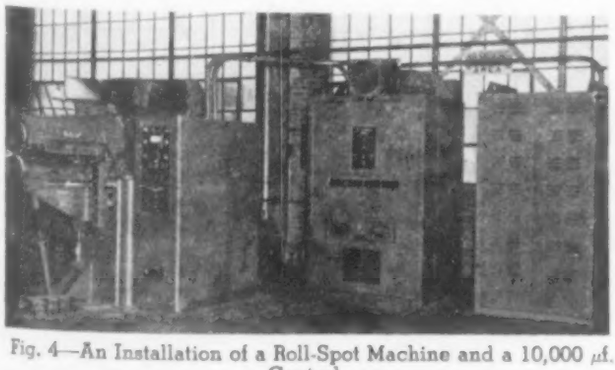

Fig. 4—An Installation of a Roll-Spot Machine and a 10,000 μf. Control

The control is built with an automatic sequence that allows adjustment of the spacing between welds by adjusting the time interval between discharges. If the time interval is small the spots will overlap and form a seam weld. The wheels never lift from the work during operation, so that it is necessary to supply the welding transformer primary current first in one polarity, then in the opposite polarity to prevent saturation of the transformer core and consequent decrease of welding current.

A machine of the roll-spot type has been built to weld materials up to $^3/_{16}$ in. thick, at the rate of 20 welds a minute. This machine will weld thinner material such as 0.016 and 0.020 in. at about 300 welds per minute. Figure 4 is a picture of this installation. Other machines of the roll-spot type using a double rectifier have been built to operate as high as 600 times per minute on thin material. These machines are used most advantageously on flat work or on work that can be continuously fed into the machine.

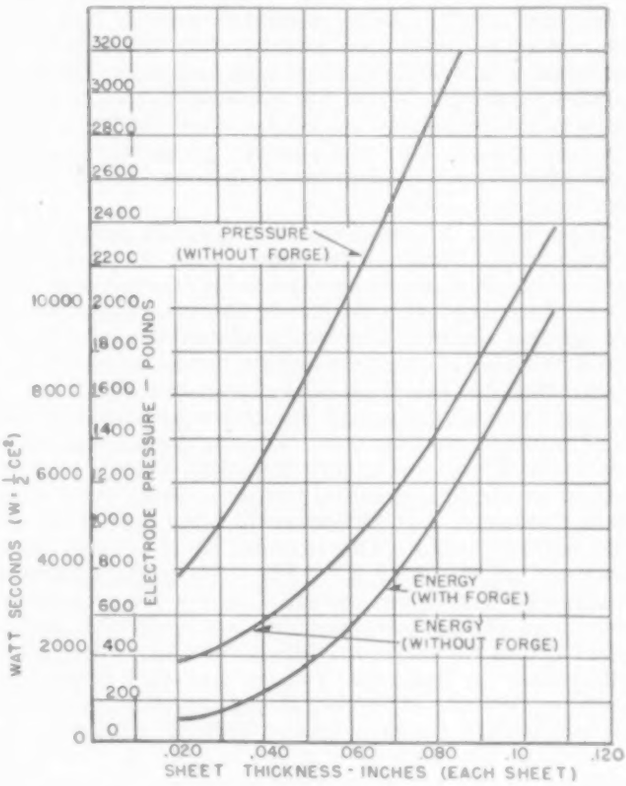

Fig. 5—Energy and Electrode Force versus Sheet Thickness for 24S-T Alclad Aluminum. The Effect of Forging on Energy Required Is Evident

Users of this type of machine find that electrode pickup is much less than on an a.-c. machine doing the same job. An example of this was noted recently when a manufacturer was welding the same item on a roll-spot machine of the energy storage type, and on an a.-c. machine. The a.-c. machine was capable of making 70 welds per minute on the item, while the energy storage machine could make only 50. However the output of the energy storage roll spot exceeded that of the a.-c. machine during a day's run because the electrode pickup was so severe and required such frequent stoppage for cleaning of the electrodes that the difference in speed of operation was more than made up.

Welding Data

Aluminum

The high thermal conductivity of aluminum makes it

necessary to supply the weld energy to the material at a very high rate so that the heat lost by conduction to the metal around the weld is small. The high rate of heating and quick forming of the weld prevents loss of temper and consequent weakening of the material around the weld. The lighter gages require fast application of weld energy, which is obtained with small capacitance, low turn ratios and relatively high voltage. This is shown in the thickness versus energy curve, Fig. 5.[1] Heavier gages require slower application of energy so that larger values of capacitance and transformer turns ratios are used. For example, a typical setup for welding two pieces of 0.020-in. 24S-T alclad aluminum would be 480 μf., at 2200 v. and a turn ratio of 150:1. Welding two pieces of 0.102-in. material requires about 2640 μf., at 2600 v., and a turn ratio of 450:1.

The pressure applied to the material to be welded is critical as it not only affects the indentation of the material, but also the heat developed in the weld. If the pressure is too low the weld "nugget" (metal actually fused between the pieces) will be excessively large, and the molten material may actually come through to the outer surfaces, with consequent high electrode pickup and surface marking. When the pressure is too high, the surfaces are excessively indented and the weld "nuggets" are too small. The approximate pressure values required for various thicknesses of aluminum are shown in Fig. 5.

From Fig. 5 it is seen that the pressure necessary to weld increases almost as the square of the material thickness. The pressure required to weld $^1/_8$-in. material is about the maximum that can be obtained with a standard welding machine. Special machines using hydraulic pressure systems have been built to handle material up to $^1/_4$ in. thick, but this is about the upper practical limit.

Forging on aluminum alloys is most beneficial on material 0.040 in. and heavier. Forging allows welding of the material with less energy than with a single pressure system as the lighter initial pressure allows more intersheet resistance, and consequently more heat to be developed in the weld. This is shown by the energy curve (with and without forging) of Fig. 5. The sheet indentation is also somewhat less than with a single pressure system as the pressure remains low until the molten metal begins to solidify. When the nugget begins to solidify and the tendency to shrink and crack is greatest, the forge pressure is applied to compress the metal and allow the weld to form free of cracks. However the strength of the material returns rapidly as the metal solidifies, so that the work is not indented as greatly as if a single high pressure had been used throughout the weld.

Before satisfactory welds can be made in aluminum, the surface of the material *must be properly cleaned.*[2] Cleaning is necessary because of the oxide which forms on the surface of most alloys (especially the Alclad materials) when they are exposed to the atmosphere. The electrical resistance of this oxide coating is relatively high and varies considerably from point to point on the surface. Consequently, when the material is placed between the electrodes of the welding machine and a discharge is made, the current passes through the material in the path of lowest resistance, which is not always directly under the electrodes. This results in expulsion of metal, welds with areas of little or no fusion and very inconsistent spot strength. Pickup (metal deposit) on the electrodes is excessive because considerable heating takes place between the electrode surface and the material. This heating causes alloying of the surface layer with the electrode, and quickly forms a layer of metal that distorts the electrode face making it useless for further welding.

Proper cleaning removes the oxide coating and produces a surface of uniformly low resistance—about ten micro-ohms for Alclad aluminum. Thoroughness of cleaning can be checked by measuring the surface resistance.[3]

Two methods of cleaning are used generally, throughout the industry. The first of these is chemical cleaning. Chemical cleaning produces excellent results in that the material can be uniformly and quickly cleaned in large quantities. The difficulty experienced with this type of cleaning is that the time the material is in the cleaning solutions is critical and must be closely checked. The concentration of the solutions themselves must be closely controlled so that the cleaning time will remain constant. Either too short or too long a time results in high surface resistance.

Wire brushing is another method of cleaning the material. This type of cleaning produces excellent results if done by an experienced operator. It is difficult to use, however, where large quantities of material are involved and much of its quality depends on the ability of the operator.

Magnesium

Magnesium welding, in general, requires slower application of the welding energy than aluminum as its electrical conductivity is only about two-thirds that of aluminum. A weld can be made in two pieces of 0.020-in. magnesium (Mg-Mn-1.5) using 120 μf. at approximately 1500 v. and a turn ratio of 450:1. For the 0.102-in. material the setting would closely approach that of aluminum of the same thickness and would be about 2640 μf. at 2800 v. and 450:1 turn ratio. The energy and pressure versus sheet thickness graph for this material is shown in Fig. 6.[4]

Magnesium alloys are usually supplied with protective coatings of either chrome pickel or oil. The oil coating is

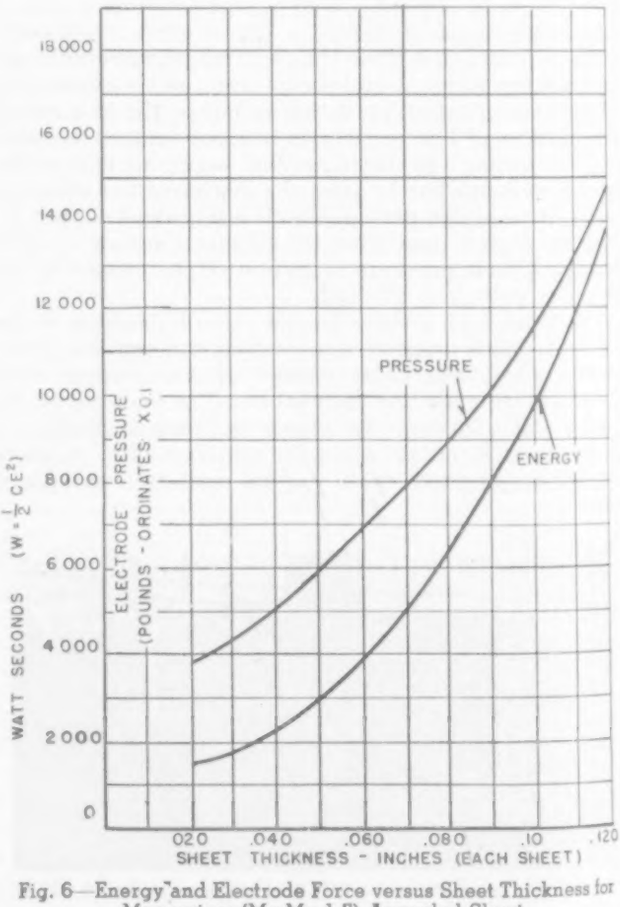

Fig. 6—Energy and Electrode Force versus Sheet Thickness for Magnesium (Mg-Mn 1.5) Annealed Sheet

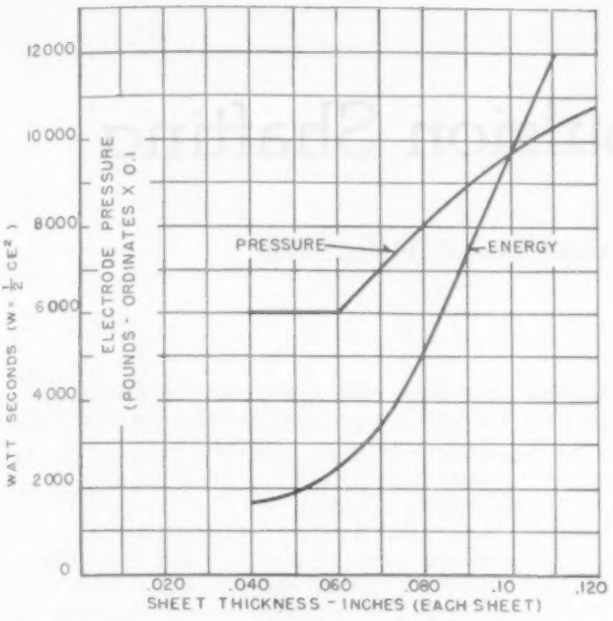

Fig. 7—Energy and Electrode Force versus Sheet Thickness for Mild Steel

easy to remove either chemically or by wiping. The chrome pickle coating is removed by wire brushing or in the case of magnesium alloys containing aluminum by the use of steel wool. Chemical cleaners for this material have not been too satisfactory.

Magnesium alloys have a great affinity for electrode material and pickup is difficult to control. When welding these materials high conductivity electrodes should be used.

Steel

The welding of steel with a capacitor discharge machine requires exceptionally long wave shapes which are obtained by using high capacity and high turn ratio with relatively low voltage. Steel welding is not nearly as critical as aluminum welding, and wide variations in settings produce good welds. The electrical conductivity of steel is about a fifth of the conductivity of aluminum, so that when the material is inserted in the secondary circuit of the welding machine it makes up a large part of the secondary circuit resistance and thus absorbs most of the energy put into the circuit. A typical setting for two pieces of 0.036-in. SAE 1010, is 1560 μf. at 1300 v. and 450:1 turn ratio. A setting to weld 0.102-in. material requires about 6650 μf. at 1700 v. and 450:1 turn ratio and results in an extremely long wave shape. The energy and pressure versus sheet thickness curves for mild steel are shown in Fig. 7.[5]

A great deal of steel welding is done with no surface preparation other than wiping off the scale and oil.

Since present experimental data indicate that large capacitance and low voltage are required for steel welding, it is possible to reduce the cost of the system by the application of proper capacitors. Further reductions in cost may be possible by using welding machines with heads similar to those used on single-phase a.-c. welders (without low inertia, calibrated pressure devices or double pressure systems).

Future Trends

Most capacitor discharge equipment available at present was designed primarily to weld aluminum; consequently, the equipment is elaborate and more expensive than comparable a.c. apparatus. The equipment is applicable also to the welding of mild steel. Since mild steel is not critical to weld, many of the special features required for aluminum welding can be eliminated. The cost of the equipment can then be reduced so that it will compare favorably with a single phase system using series capacitors and a voltage regulator.

Undoubtedly the electrical power obtainable will be limited in many localities for some time to come. Therefore, it is reasonable to expect that capacitor discharge welders will be used for welding materials other than aluminum in the future.

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(*Continued on page 1045*)

Welding of Propulsion Shafting*

By Hugo W. Hiemke† and Commander James C. Blake, USNR‡

Introduction

BEFORE the Navy's shipbuilding program could gain momentum in 1940 and 1941, many production bottlenecks, especially those arising in connection with the procurement of machinery and equipment items, had to be broken up. The difficulties were aggravated by the simultaneous expansion of the merchant shipping program. Ship shafting was one of the most important items for which the demand exceeded the capacity of existing production facilities. Few people realize the magnitude of the job of supplying shafting for a single escort vessel, for example. One of these relatively small warships requires 225 ft. of shafting, aggregating 30 tons of steel. Now multiply this by 1000 ships and it is obvious that a man-sized manufacturing problem is involved. When it is recalled that the nation's shipyards were also turning out battleships, aircraft carriers, cruisers, destroyers, submarines, cargo vessels, oil tankers, troop transports by the hundreds and landing craft and assault boats by the thousands, and that each one needed its share of shafting, the sizes, types and quantities reach astronomic proportions.

Ship shafting has traditionally been a high-quality forged product, of high physical properties, frequently a $3\frac{1}{2}\%$ nickel steel. Nearly all shafting steel has a carbon content between 0.35 and 0.45%, both in the carbon steel and alloy steel grades. Since the shafting of naval vessels is part of the main propulsion machinery system, it is subject to very careful inspection. Modifications in design, materials or methods of construction must be carefully scrutinized before being adopted. No change can be made unless an important advantage can be gained by its adoption.

Shafting from Formed and Welded Plate

With enormous production requirements on the one hand, and the need for great care in evaluating new methods on the other, a survey of manufacturing methods for ship shafting was instituted by the Bureau of Ships in September 1940. One of the methods which appeared to have promise involved the fabrication of large diameter shafting by "boiler drum" methods. This involved the forming of two semi-cylindrical sections from heavy alloy steel plate, welding these halves together with two longitudinal welds and then welding forged flanges to the ends of the cylindrical section by means of circumferential welds. A number of conferences were held with representative fabricators and the plan was finally abandoned for the following reasons:

(*a*) Forming presses capable of producing the long, semicylindrical sections were almost as scarce as forging facilities.

(*b*) Facilities for welding thick-walled alloy steel sections were also scarce and were fully occupied with other important war work.

(*c*) The desired dimensions of the shafting (very heavy wall and relatively small inside diameter) had to be produced by welding from the outside only. Inspection of the bottom of the root weld would be impossible.

(*d*) Alternatively, the shafting could be made with larger inside (and outside) diameters to facilitate root chipping, root inspection and rewelding. The increased outside diameter would have required complete redesign of struts, stern tubes, bearings and shaft bearing saddles.

Centrifugally Cast and Welded Shafting

Soon after it became apparent that the formed and welded shafting would have to be abandoned, it occurred to one of the authors that the fabrication of shafting by welding together centrifugally cast tubular sections and flanges might be a promising solution. The Army Ordnance Department used centrifugally cast gun barrels—why should not this method be adopted for the manufacture of shafting? The more the proposition was analyzed, the more attractive it sounded. Accordingly, it was decided that a line shaft section for a minesweeper be fabricated by welding flanges onto a centrifugally cast center section.

The next question was to get a suitable centrifugal steel casting. Since the problem was to replace a steel forging, there should be no doubt as to the soundness or metallurgical quality of the product. It was quite natural to turn to Watertown Arsenal for help, since they, too, were substituting a casting for a forging in gun tubes, in which the metallurgical quality had to be of the highest order. After conferring with the responsible officers at Watertown, it was found that a minesweeper shaft, flanges and all, could be machined out of a 90-mm. gun casting. One of these castings was shipped to the Naval Engineering Experiment Station at Annapolis, Md., where the casting was cut up, rough machined, welded and finish machined. Figure 1 shows the layout and method of assembly of this shaft section.

When the feasibility of producing ship shafting by this method had been demonstrated, the next step was to find a source of supply for shafting in quantity, capable of producing to the high quality standard necessary for main propulsion machinery. After several unsuccessful attempts, it was found that the American Cast Iron Pipe Co., of Birmingham, Ala., had the necessary facili-

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* The opinions expressed in this article are the private opinions of the authors and are not to be construed as the official opinions of the Navy Department. Scheduled for the Twenty-Sixth Annual Meeting, A.W.S., October 1945.

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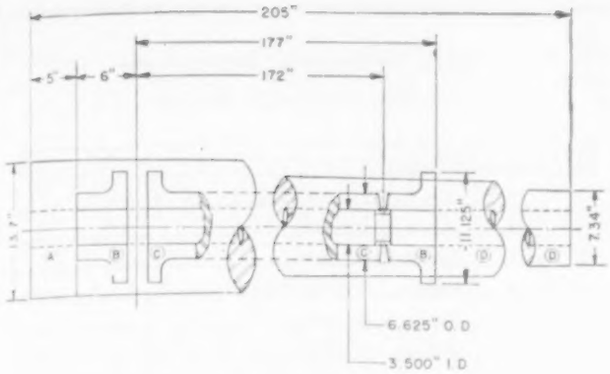


NOTES:
1. PIECE (A) TO BE CUT FROM BREECH END OF CASTING FOR PHYSICAL TESTS.
2. PIECE (B) TO BE CUT FROM BREECH END AND WELDED TO MUZZLE END OF PIECE (C) IN THE POSITION SHOWN.
3. PIECE (D) AVAILABLE FOR PHYSICAL TESTS.

Fig. 1—Centrifugally Cast Shaft Made from 90-Mm. Gun Casting

ties and know-how for making the castings. At that time, this company was not prepared to do the welding, although subsequently, welding facilities were installed. Accordingly, an experimental contract was arranged in which the centrifugal castings were furnished by American Cast Iron Pipe Co. and the welding, heat treating and machining were done by the Charleston Navy Yard, Charleston, S. C.

This first contract was for destroyer escort shafting. When this contract indicated the feasibility of producing centrifugally cast and welded shafting on a production basis, another contract for tug shafting was arranged. In this case, all of the work including the welding was done by the casting manufacturer.

The next step was to get a service test. By the time that the shafting had been installed in ships, and 6 mo. of operating time at sea had elapsed, the procurement problem was no longer critical, so the opportunity for widespread use of the method had been lost. But the feasibility of the method and its suitability in service have been demonstrated. In the opinion of the writers this method of manufacture offers economies without the sacrifice of quality, which will give it a real postwar future.

Comparison of Forged and Centrifugally Cast Shafting

The function of ship shafting is to transmit torque from the propulsion machinery to the propeller. The shear stress in a cylindrical member under torsional loading may be represented by the following formula:

$$S_s = \frac{QD}{2J} = \frac{16}{\pi}\left(\frac{QD}{D^4 - d^4}\right)$$

in which

S_s = unit shear stress, psi.
Q = torque, in.-lb.
D = outside diameter of shaft, in.
d = inside diameter of shaft, in.
J = polar moment of inertia (in.^{4})

It should be noted that the inside fibers of a hollow shaft transmitting torsional loads are subject to a relatively low unit stress, the ratio of shear stress at the inside fibers being $^1/_2$ that of the shear stress at the outside surface (where the I.D. is $^1/_2$ of the O.D.). In view of this situation, and the fact that the Navy is always concerned with weight saving when this can be accomplished without sacrifice of reliability of operation, most large shafts for naval vessels have, in recent years, been bored to an I.D. of approximately $^6/_{10}$ of the O.D.

In a forged shaft. this saving in weight has been obtained at a considerable increase in cost. For this reason, hollow shafting has been used only on combatant vessels, where the weight saving was most important.

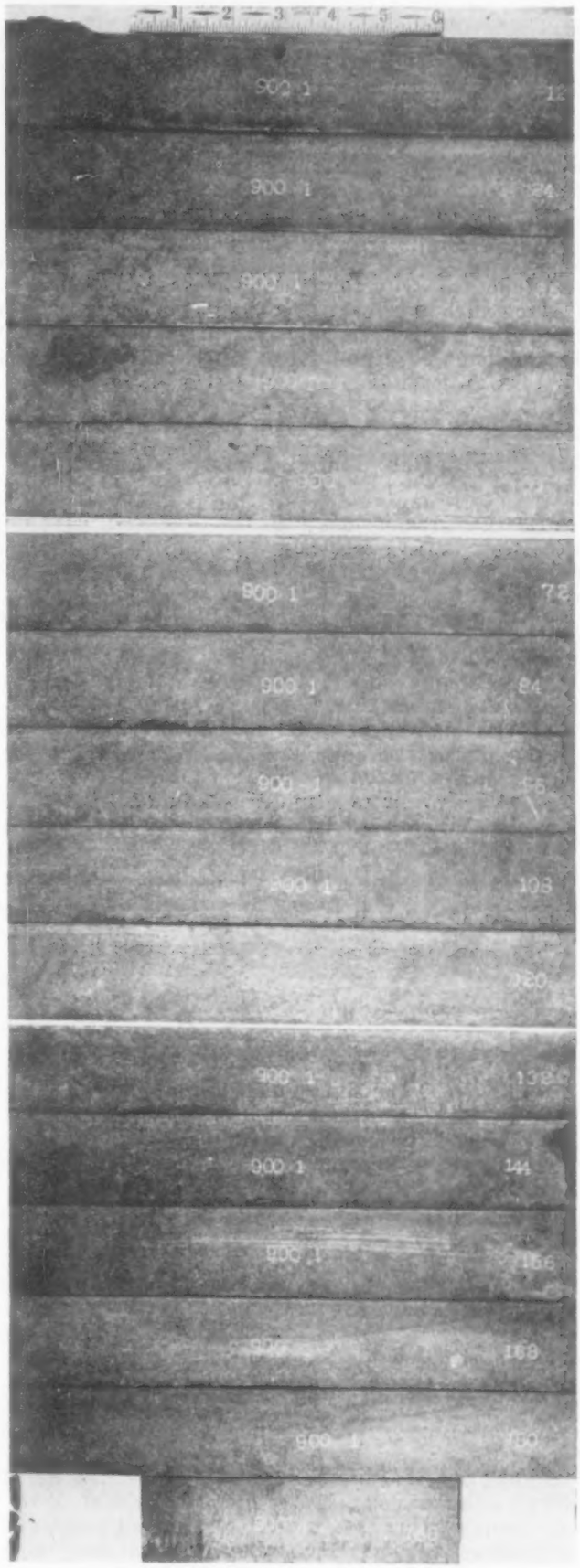


Fig. 2—Sections of Cast Hollow Shafting

In the case of centrifugally cast shafting, however, the hollow cylindrical shape is produced as a characteristic of the manufacturing process; therefore, it is not necessary to pay a premium for this weight-saving feature. In applying this process to the manufacture of ship shafting, it is entirely feasible to apply the hollow shaft principle to all sizes.

Another important advantage which results from the use of the centrifugal casting process, as compared to forging, is the reduced machining cost. Balance and straightness are necessarily developed in centrifugal casting by the nature of the process. If the castings were not balanced, they would destroy the spinning machine in which they are produced. By maintaining the initial balance and straightness in the subsequent cooling, heat-treating and welding processes, a shaft can be delivered to the machine shop which requires a very minimum of finish allowance. On the escort vessel shafting, each forged shaft required 24 hr. more machine time than the centrifugally cast and welded shafting. This difference amounted to approximately a 30% decrease in machining cost.

Quality Control and Inspection

Great care was exercised in the development of this process of shafting fabrication, to be certain that the physical properties and soundness of the castings and the welds were of the highest possible order.

The development and control tests used in the course of this project included the following:

(*a*) Sectioning and destructive testing of the centrifugal castings.
(*b*) Development of chemical analysis needed for the physical properties.
(*c*) Development of casting technique for flanges.
(*d*) Development of welding procedure.
(*e*) Radiographic and magnaflux inspection of castings and welds.
(*f*) Torque test of a finished shaft.

These six phases of the project will be discussed in detail in the following paragraphs.

Testing of the Cylindrical Castings

An initial series of five castings, 9 in. O.D. x $4^1/_2$ in. I.D. x 16 ft. long were cast, and examined destructively. A 1-in. wide slab was cut from each shaft for the entire 16 ft. length and after cutting into 12 in. lengths, the slabs were deep-etched. The etched sections were remarkably sound, as will be seen from the photograph (Fig. 2). The inside surface was found to be somewhat rough, but not severely notched. A chemical segregation occurs in the last $^1/_8$ in. of metal to solidify (next to the inside surface). Since the unit stress on these inside fibers is only $^1/_2$ of that occurring on the outside of the shaft, this segregation was considered to be unimportant.

No evidence of cracking or surface overlapping was apparent in these centrifugal castings. Since the castings are made in sand molds, such defects in the cylindrical sections of the shaft castings are not likely to occur.

The degree of chemical segregation was determined on several of the castings. Table 1 shows carbon and sulphur contents from the inside to the outside surface of six castings as well as the complete chemical analysis at the center of the section.

Table 1—Chemical Segregations

Results of Chemical Analysis

Shaft No.	Section	Position of Sample	C	S	P	Mn	Si	Al	Cr	Mo	Ni	Si
1	A	Center	.23	.036	.024	.57	.39	.01	.03	0	0	0
	"	Inside	.22	.042								
	"	Outside	.24	.039								
	B	Center	.22	.032	.023	.64	.46	.01	.02	0	0	0
	"	Inside	.24	.037								
	"	Outside	.18	.029								
2	A	Center	.26	.022	.018	.67	.34	.01	.01	.51	0	0
	"	Inside	.26	.017								
	"	Outside	.24	.016								
	B	Center	.27	.02	.013	.72	.36	.02	.02	.48	0	0
	"	Inside	.34	.043								
	"	Outside	.21	.024								
3	A	Center	.25	.025	.02	.68	.44	.21	.10	1.01	.10	0
	"	Inside	.24	.027								
	"	Outside	.24	.025								
	B	Center	.30	.028	.02	.77	.46	.12	.09	1.0	.11	0
	"	Inside	.28	.033								
	"	Outside	.20	.024								
4	A	Center	.24	.025	.02	.77	.51	.11	.05	.56	.18	0
	"	Inside	.23	.026								
	"	Outside	.26	.021								
	B	Center	.25	.015	.02	.74	.46	.11	.07	.49	.15	0
	"	Inside	.25	.027								
	"	Outside	.23	.023								
5	A	Center	.24	.029	.025	.80	.56	.11	.04			
	"	Inside	.29	.029								
	"	Outside	.24	.033								
	B	Center	.24	.036	.025	.87	.58	.09	.04			
	"	Inside	.28	.041								
	"	Outside	.24	.032								
6	C	Inside	.45	.057	.028	.78	.35	.02	.03			
	"	Outside	.29	.039	.03	.72	.30	.03	.02			
	"											
	B	Inside	.33	.045	.035	.77	.48	.01	.03			
	"	Outside	.22	.036	.016	.75	.44	.03	.02			
	"											

A - Section taken from end of shaft opposite cast flange for shafts #1, 2, 3 and 4. In the case of shaft #5 which had no flange, one end section is also designated A.

B - Section taken from near midlength of all shafts.

C - Section taken adjacent to welded on flange section of shaft #6.

Development of Physical Properties

Two types of tension test specimens were made in this study—separately cast coupon test bars, and test bars machined from the actual castings. The coupon bars were made as a check of melting practice, to compare with the routine tests made on each heat of static castings. The bars machined from the actual castings were an exact measure of the properties of the product. While such tests are rarely conducted on cast articles, it is customary to conduct such tests on forged shafting, and it was considered essential that the tests of the castings be made in a manner identical with that which is customary in acceptance testing of forgings.

Because of the greater mass of the shafting as compared to separately cast test bars, the yield point and

tensile strength of the specimens cut from the shafting was usually lower by 2000–5000 psi. than the corresponding properties of the coupons. Table 2 shows the comparison of average properties representing mean values of 40 or more determinations for each value recorded in the table. It will be noted that the elongation in 2 in. and the reduction in area of the shafting specimens tended to be lower also.

Table 2—Average Values of Physical Properties, Centrifugally Cast Shafting

	Specimens Cut from Shafting		Separately Cast Coupons
	Longitudinal	Transverse	
Yield point, psi.	46,500	44,600	49,100
Ultimate tensile strength, psi.	76,500	75,900	79,400
Elongation in 2 in., %	23.4	22.5	27.1
Reduction in area, %	40.8	37.5	45.7

NOTE 1: Values for shaft specimens represent average of 43 tests with average chemical analysis of 0.291% carbon and 0.884% manganese.

NOTE 2: Values for separately cast coupon specimens represent average of 130 tests with average chemical analysis of 0.291% carbon and 0.754% manganese.

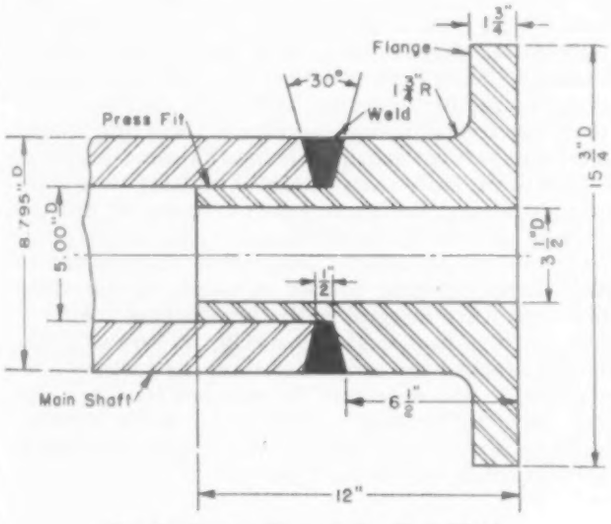


Fig. 3—Section Through the Shaft Weld

As a result of the experience gained in this study, the following chemical analysis and physical properties were specified for the shaft castings, as determined by specimens cut from the shafting itself.

C	0.35% max.
Mn	1.10% max.
P	0.05% max.
S	0.05% max.
Ultimate tensile strength	90,000 psi. max.
Yield point	37,000 psi. min.
Elongation in 2 in., %	15% min.
Reduction in area, %	30% min.
Bend test	120° min.

Development of Flanges

In the initial stages of this development, an effort was made to cast each 16-ft. section of shafting with one integral flange. It was soon found, however, that it was preferable to cast the long sections as simple cylinders,

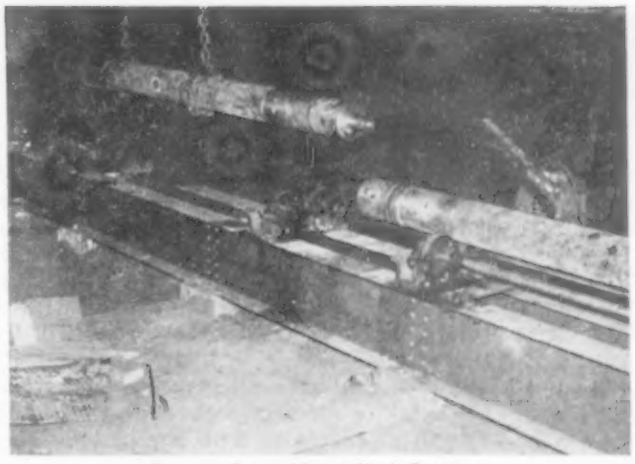


Fig. 4—Assembly of Shaft Sections

with the spinning axis horizontal, and to cast the flanges separately. The integrally cast flanges were found to be subject to occasional circumferential cracks on the outside surface, or just below the outside surface of the flange, at its heaviest cross section. By casting the flanges with the spinning axis vertical, and providing adequate feeding, flange castings entirely free from cracks have been produced. These castings are subjected to magnaflux examination during the various stages of manufacture, to be certain that they do not contain surface defects. Destructive examination of a number of these flange castings has shown that internal shrinkage cavities are practically nonexistent.

Development of Welding Procedure

The welding procedure adopted for joining the centrifugal castings was based on experimental work performed at the Naval Engineering Experiment Station at Annapolis, Md. This work had demonstrated the importance of a close fitting backing ring and liberal root opening if a sound first pass is to be deposited. The thick weld in a relatively small diameter combined with considerable hardenability of the base metal made it imperative to follow a rigidly prescribed procedure for all of the welding.

The joint design details are shown in Fig. 3. Figures 4 and 5 illustrate the assembly of the shaft sections and the backing ring to form the groove for welding. Since a close fit is required, the O.D. of the ring and the I.D. of the shaft are both machined before assembly.

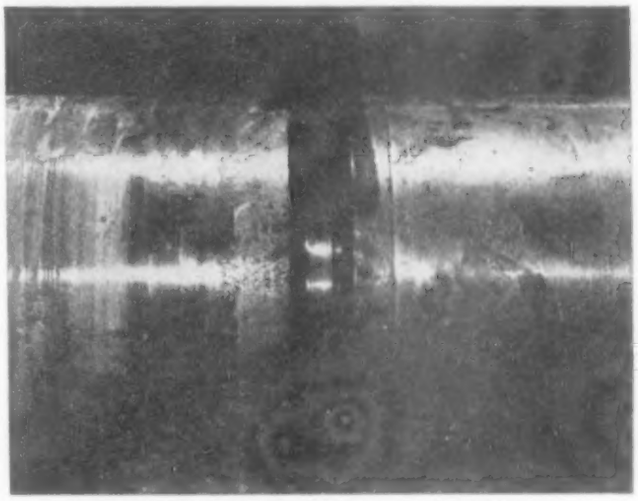


Fig. 5—Weld Groove, Backing Ring in Place

All weld zones were preheated before proceeding with welding. The shaft was rotated during preheating to assure a uniform distribution of heat. A temperature of 300° F. was used, and this temperature was maintained at all times during the progress of welding.

The first pass of weld metal was deposited with an E 6010 type of electrode, using a beading technique of deposition. This electrode was used because of its tendency to form a convex bead, thus producing a weld metal cross section which is best able to resist the shrinkage stresses and notch effects of the solidifying first pass. The remainder of the weld was made with a Navy Class 2 type of electrode (either E 6020 or E 7020), using a weaving technique. The 7020 was used in some cases because it supplied a slightly higher margin of strength. Either electrode produces weld metal having a yield strength in excess of that required for the base metal.

All welding was done in the flat position. The shafting was rotated by means of a motor, under the control of the welding operator, keeping the pool of molten weld metal just back of dead center. The layers of weld metal were deposited by means of a split-pass technique, rather than being woven across the entire joint.

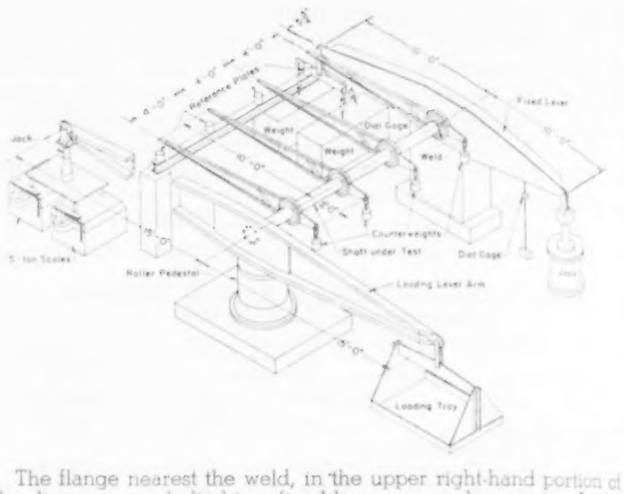
After the welding was completed, the welds were post-heated at 1100° F. for 4 hr. in a local heat-treating furnace. To avoid misalignment of the shaft, the shaft was rotated slowly during the heat-treating operation. Figure 6 illustrates the local heating equipment used to perform this operation.

Radiographic and Magnaflux Examination of Castings and Welds

The completed welds were examined by means of gamma-ray radiography, to guard against possible gross internal defects. Because of the thick wall and small diameter of the shafting involved, radiographic examination could not be expected to be sensitive for locating very small defects. On the basis of the examination made, the internal integrity of the welds was found to be excellent.

Magnaflux examinations were conducted on the first pass of the welds, and again after the weld was completed. The final magnaflux examination was made after rough machining of the shaft in way of the weld.

Fig. 6—Local Heating Equipment



The flange nearest the weld, in the upper right-hand portion of the diagram, was bolted to a fixed lever arm and support. At the opposite or near end in the diagram, the shaft rested on rollers, and a loading lever arm extending 15 ft. on either side of the shaft was bolted to the flange. From one end of the loading lever arm a tray was suspended, upon which lead weights were placed to give load increments. A jack supported on scales pushed upward on the other end of the loading lever arm.

Fig. 7—Arrangement of Test Apparatus

This examination was conducted primarily for surface cracks. Under the controlled conditions of welding used in fabricating this shafting, weld cracks were rarely encountered. Such defects as were located were minor in character, usually associated with weld craters.

A complete magnaflux examination was also made on the entire shaft casting, just before finishing machining. On some of the early shafts, nests of porosity were located by magnafluxing, but these were overcome by providing a slightly greater finish allowance. Also, as was stated in a previous paragraph, magnaflux examination did locate circumferential cracks on some of the flanges which were cast integral with the shafting. After the flange castings were cast separately, no serious difficulties with cracks were encountered on the castings. In a few cases, it was necessary to chip out local areas and repair them by welding. Such repair welds were heat treated in a manner similar to the treatment given the main circumferential welded joints.

Torque Testing of Finished Shafting

After the first centrifugally cast and welded shaft had been finish machined, it was considered desirable to subject it to a full-scale torque test to destruction. This test was conducted at the Charleston Navy Yard. The shaft exhibited the same shearing modulus of elasticity as a conventional forged shaft. It behaved in a perfectly elastic manner up to a shearing unit stress of 19,000 psi., at which point a permanent detrusion (set) took place. This yield point corresponds to a tensile yield point of 38,000 psi., which was almost exactly the yield point of the tensile test coupon cut from a section of the centrifugal casting from which the shaft was fabricated. Figure 7 illustrates the test arrangements for conducting this full scale torque test.

Conclusion

The most convincing proof test of any fabricated article is a life test under actual service conditions. Shafting fabricated by the methods described in this article have been operating on naval vessels for periods

of 5–14 mo. without incident. It is recognized that this time period is short, compared to the normal life of ships' propulsion shafting but, on the other hand, sufficiently long, it is believed that any serious difficulties would have been exposed by this time if they existed.

The use of centrifugally cast and welded shafting appears to be entirely practicable for highly stressed applications such as ships' propulsion shafting.

(*Continued from page 1039*)

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Welding of Combat Vehicles

By 1st Lt. L. M. Dalcher*

FOR the past 4 years, all tanks, self-propelled weapons and other combat vehicles manufactured for the Armed Forces of the United States have been of welded construction. By this is meant that welding has been used as the joining process for practically all joints subject to direct or indirect ballistic attack, where failure of the joint might incapacitate the vehicle or cause bodily injury or loss of life to the using troops. Nearly all other metal-to-metal joints in these vehicles have likewise been welded. When it is considered that during the past three years the Army Service Forces have procured over 75,000 tanks, over 40,000 self-propelled weapons and over 100,000 miscellaneous combat vehicles, it will be realized that the importance of welding to modern warfare can scarcely be overestimated.

In controlling this vast amount of welding, the Ordnance Dept., Army Service Forces, has utilized to advantage the principle of the Ordnance-Industry team. This principle or policy operates on the premise that industry possesses the requisite technical knowledge and production "know-how," and is capable of producing war matériel of satisfactory quality and in sufficient quantities if the Ordnance Dept. indicates clearly what is needed. The principle is simple, and it has worked. The purpose of this article is to indicate how it has worked in the field of welding, and to illustrate certain forms which the Ordnance Dept. has found useful and which may prove valuable in connection with commercial, non-Ordnance welding.

Design of Combat Vehicles

Some types of Army vehicles are not originally designed in detail by the Ordnance Dept., but are purchased from commercial concerns who have themselves worked out the design in such a manner as to produce a vehicle complying with certain military characteristics which the Ordnance Dept. has prescribed. Jeeps, trucks, tractors and trailers have nearly all been procured in this manner. In the case of tanks, gun motor carriages and similar vehicles, however, the Ordnance Dept. has reserved to itself the complete responsibility for the design of the vehicles. This was necessary because such vehicles have to meet service requirements of a very unusual nature as compared to commercial vehicular operation, and because industry did not possess a background of experience in designing or producing such vehicles.

The designing of a vehicle necessarily involves working out the details of the welded joints. In the case of a combat vehicle, as has been said, the Ordnance Dept. performs this function. This does not mean that the Ordnance Dept. decides how the *welding* shall be done. The design of the *joint* involves decisions as to the location of the joint in the vehicle; the nature of each individual joint, whether butt, lap, corner, edge or tee; the type of weld, whether single-bevel, double-bevel, single-vee or double-vee, etc.; and such dimensional details as the root opening, included angle and size of fillets.

* Ordnance Dept., ASF.

How the welding will be done is left to the concern that will actually fabricate the vehicle. In this way the individual contractor is encouraged to select his own welding processes, whether a.-c. or d.-c., manual or automatic; to devise his own welding procedures; to select whatever kinds and sizes of electrodes he believes will work most satisfactorily; and to recommend joint design changes which will simplify his operations or improve the quality of the vehicle.

Welding Controls

Since the details of welding are left to the discretion of the individual contractor, some form of control by the Ordnance Dept. is required to insure that the welded joints of production vehicles will actually be satisfactory, both from a structural and from a ballistic standpoint. This is particularly true because most of the important joints in a combat vehicle involve the welding of armor, which is a much more precarious operation than welding ordinary mild steel. Control by means of X-ray examination of every weld, even if practicable, would not be entirely satisfactory, for the reason that soundness alone provides no assurance of the *ballistic properties** of a weld. The methods of control employed by the Ordnance Dept. are of five types, namely:

1. Review of contractors' welding procedures.
2. Qualification tests of welding procedures.
3. Qualification tests of welding operators.
4. Inspection of welding in progress.
5. Inspection of completed welds.

* The term *ballistic properties*, when used in this sense, refers to the ability of a welded joint to resist the shock and penetration incidental to the impact of a projectile.

Fig. 1—Medium Tank M4 (the "General Sherman"). This Was the Principal Tank Employed in the North African Operations and in the European Invasion

Fig. 2—76-Mm. Gun Motor Carriage M18 (the "Hellcat"). This High-Speed Tank Destroyer Was Employed Effectively in the European Invasion

Review of Contractors' Welding Procedures

The U. S. Army specification which covers the welding of armor is similar to many other welding codes and specifications (e.g., the A.S.M.E. Code for Unfired Pressure Vessels; the A.S.A. Code for Pressure Piping; the A.W.S. Code for Arc and Gas Welding in Building Constructions; etc.) in that it requires the contractor to establish and record the welding procedures which he intends to employ in production. The factors which must be included in such welding procedures are the same as those prescribed in other welding codes, namely: composition and thickness of base metal; dimensions of root opening, root face and included angle; position in which the welding will be performed; type and size of electrodes; source of power, whether a.-c or d.-c.; welding current range and voltage range; location and number of passes; preheating temperature; etc. These written welding procedures are submitted by each contractor to the Chief of Ordnance for review prior to qualification of the procedures or welding operators.

Ordnance review of these welding procedures consists chiefly of checking the joint designs for conformance with the applicable drawings, and seeing that the contractor has not omitted any important factor. In addition, comment may be made if some specific detail of the procedure seems irregular or unreasonable, as for example if the range of welding current for a given size of electrode is unusually wide. (Recommended maximum current variations, plus or minus, for electrodes of various sizes: 15% for $^{5}/_{32}$-in. electrodes, 10% for $^{3}/_{16}$- and $^{1}/_{4}$-in. electrodes, 5% for $^{5}/_{16}$- and $^{3}/_{8}$-in. electrodes.) There are two other important reasons for requiring the contractor to prepare written welding procedures. The first is that it calls to his attention the fact that there are a large number of variables that must be controlled within reasonable limits if uniformly satisfactory welds are to be obtained. The second is that it provides something tangible which the Ordnance inspector can use to ascertain whether production welding is being carried out in accordance with the contractor's declared welding procedures.

Qualification Tests of Welding Procedures

Before a welding procedure is used in the fabrication of a combat vehicle, it must be qualified by means of certain prescribed tests. The principle and purpose of such tests are the same as in the case of welding pressure vessels, bridges, buildings or other important structures. In this case, however, since the application is distinctly different, the actual test requirements are also different. The details of the qualification test plate cannot be revealed at this time. Nevertheless, it may be stated that the test plate is welded by the contractor in accordance with his recorded welding procedure, and then tested for soundness and ballistic properties. The test plate must pass both a radiographic examination and a ballistic test before the procedure is considered qualified.

A procedure once qualified may be used indefinitely, and for any vehicle, unless the contractor decides to make a change in the procedure. Specification requirements provide that a minor change which is not likely to affect the properties of the weld may be made without requalifying the procedure. A major change, however, requires that the new procedure be qualified in the same manner as the original. The Ordnance Dept. has endeavored to reduce the number of requalification tests to a minimum consistent with safety. One method of accomplishing this objective has been to provide that requalification is not required in the case of a change in electrode brand, provided the new brand and the original brand have both been qualified under some one grade, class and type of an Ordnance Dept. or U. S. Army electrode specification. These electrode qualification tests are conducted at a Government laboratory, and lists are issued showing the commercial brands of electrodes that have been qualified under a given electrode specification. Thus it is possible for a contractor to change from one to another electrode on the same list, without requalifying his procedures.

Standardization in Ordnance Welding

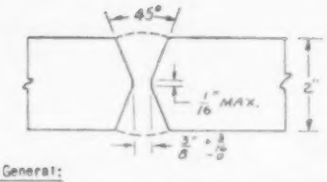
Shortly after the United States entered the present war, the Ordnance Dept. took steps to fill the need for

Fig. 3—Heavy Tank M26 (the "General Pershing"). This New Tank Saw Action During the Later Stages of the European Invasion

Welding Procedure No. 1

Joint A-A

Details of joint



Welding Procedure - General:

Base Metal SPECIFICATION XYZ, MADE BY MFR "X".

Heat Treatment of Base Metal 1650°F. WATER QUENCH, TEMPER 800°F. 2 HRS.

Electrode "SUPERARC," MADE BY MFR "Z".

Power Source (AC or DC) and Polarity if DC DC, REVERSED

Use of Spatter Compound on Scarfed Edges NONE

Backing COPPER

Preheating NONE

Position of Welding FLAT

Postheating NONE

Details of Welding Procedure:

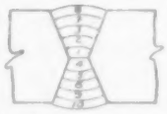
Pass No.	Electrode Size	Welding Current	Arc Voltage	Type of pass	Location & Sequence of Passes
1	3/16	150-185	23-29	BEADING	 NOTE: ROOT OF WELD SHALL BE GROUND TO SOUND METAL BEFORE DEPOSITING PASS No 4.
2, 3	1/4	200-245	24-30	WEAVING	
4	3/16	150-185	23-29	BEADING	
5, 6	1/4	200-245	24-30	WEAVING	
7 to 10	5/16	310-340	25-32	WEAVING	

Fig. 4—Primary Modification of Form Used for Recording Welding Procedures

Note: The data shown on this form are purely fictitious and intended simply to illustrate how the form might be filled in.

Ordnance Dept. standards and specifications relating to welding. Fortunately the AMERICAN WELDING SOCIETY as well as other technical societies had been developing many such standards over a period of years. Inasmuch as those standards had reached a considerable degree of perfection and had been used extensively by American industry, the Ordnance Dept. was glad to adopt them as the basis for many Ordnance specifications. As an example, it may be cited that the present Ordnance Dept. standards for welding symbols and welding nomenclature and definitions are identical with those issued earlier by the AMERICAN WELDING SOCIETY. The Army has also employed the A.W.S.-A.S.T.M. Specification for Iron and Steel Arc Welding Electrodes as the basis for a U. S. Army specification.

This cooperation between the Ordnance Dept. and the technical societies has been continued. It is a policy of the Ordnance Dept. to coordinate its standards and specifications with Industry before they are published, and the technical societies have afforded an excellent medium for this coordination. Another example of this cooperation was the appointment by the AMERICAN WELDING SOCIETY of an A.W.S.-Army Ordnance Advisory Committee to assist the Ordnance Dept. wherever possible on matters pertaining to welding. This committee has already prepared a comprehensive "Ordnance Inspection Handbook for Manual Metal Arc Welding," which was published by the Ordnance Dept. somewhat over a year ago.

Standard Form for Recording Welding Procedures

Earlier in this article it was indicated that one of the welding controls exercised by the Ordnance Dept. is the review of the contractors' welding procedures prior to their use in production. The difficulties which this

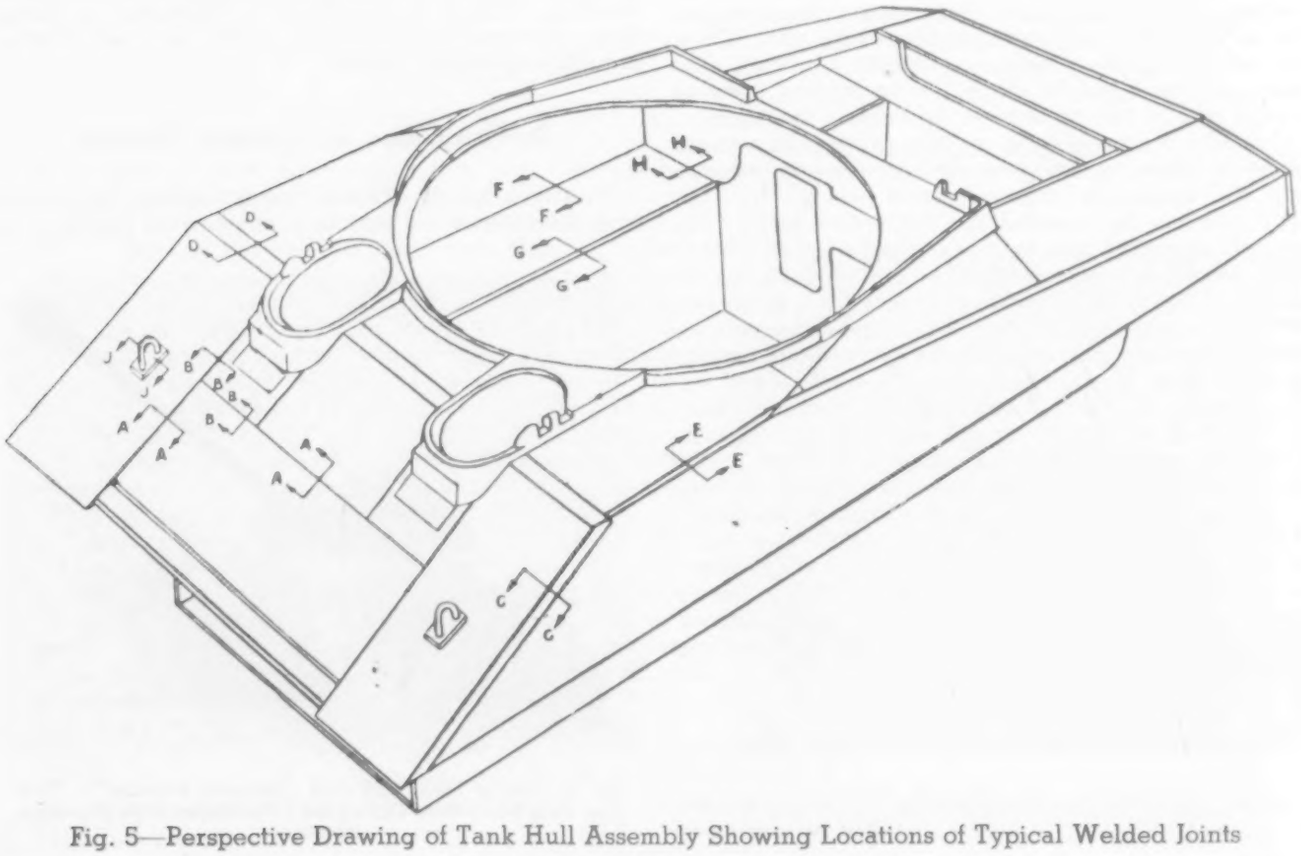


Fig. 5—Perspective Drawing of Tank Hull Assembly Showing Locations of Typical Welded Joints

Table I—Summary of Welding Procedure Qualification Tests

Joint Designation	Type of Joint	Base Metal Reference Designation†	Welding Procedure No.	Status of Procedure Qualification Tests in Each Welding Position			
				Flat	Horizontal	Vertical	Overhead
A-A	Double-V groove butt joint	I	1	Passed (Plate No. 17)	Not tested	Not tested	Not tested
B-B	Double-V groove butt joint	I and III	2	Passed (Plate No. 18)	Not tested	Not tested	Not tested
C-C	Double-V groove corner joint, fillet reinforced	I and II	3	Passed (Plate No. 19)	Not tested	Not tested	Not tested
D-D	Single-V groove butt joint	I and II	4	Passed (Plate No. 20)	Not tested	Not tested	Not tested
E-E	Double-V groove corner joint, fillet reinforced	II	5	Passed (Plate No. 21)	Not tested	Not tested	Not tested
F-F	Single-V groove corner joint, fillet reinforced	II	6	Passed (Plate No. 22)	Not tested	Not tested	Not tested
G-G	Single-V groove corner joint, fillet reinforced	II	7	Passed (Plate No. 22)	Not tested	Not tested	Not tested
H-H	Fillet-welded tee joint	II	8	Passed (Plate No. 23)	Passed (Plate No. 25)	Not tested	Not tested
J-J	Fillet-welded tee joint	I and II	9	Passed (Plate No. 24)	Passed (Plate No. 26)	Not tested	Not tested

* The data shown in this table are purely fictitious and intended simply to illustrate how the table might be filled in.
† See Table II.

policy might have introduced may readily be imagined. The problem of devising some method of presenting all the pertinent factors of a welding procedure might have perplexed many an Ordnance contractor or subcontractor. He had to indicate the composition and thickness of the armor or armors to be joined; the dimensions of root opening, root face and included angle; whether a backing or spacer strip was to be used; the position in which the joint was to be welded; the grade, type and class of electrode; the type of current, whether a.-c. or d.-c., and polarity if d.-c.; the size of electrode for each pass; the welding current range and arc voltage range for each pass; the location and number of passes; the preheat temperature, if any; the method of preparing the root of the joint before welding the second side; and any other pertinent factors. Furthermore, the problem was directly multiplied by the number of joints involved, for this same information had to be supplied for every important joint in the structure. Not only would this have been a serious problem for the dozens of Ordnance contractors and subcontractors working on combat vehicles; it would also have meant a nearly impossible task for the Ordnance Dept., whose job it would have been to review thousands of welding procedures presented in possibly a hundred different fashions.

To preclude any such possibility, the Office, Chief of Ordnance—Detroit, evolved and presented to Ordnance contractors a standard form for recording a welding procedure. Figure 4 illustrates the form in its primary modification. What it represents is an attempt to devise the simplest possible form for recording a complete welding procedure.* It will be noted that all of the factors called for in most welding codes and specifications have been included, and that nevertheless the form is uncluttered and the information conveyed is simple to comprehend and analyze.

In preparing a complete set of welding procedures for an entire vehicle, it is advisable to employ an isometric or perspective sketch of the entire structure, as illustrated in Fig. 5. This sketch is then used as a key to the individual welding procedure forms, one of which should be filled in for every different joint in the structure.

In connection with the use of these forms, it has been found desirable to prepare summaries similar to those illustrated in Tables I, II, and III. The tabular summary illustrated in Table I, although not specifically required by the Ordnance Dept., is nevertheless almost indispensable to this system of recording welding procedures, as it provides in one place a complete picture of the various joints involved and the positions of welding that have been qualified for each joint. The summary here illustrated serves the following purposes:

1. It indicates the type of weld for each joint in the structure. (Qualification of the welding procedures is ordinarily based on weld types.)
2. It provides an index to the detailed welding procedure for each joint.
3. It indicates the kind of base metal in each joint.
4. It simplifies the problem of determining the mini-

* Strictly speaking, the writer should perhaps use the term *joint welding procedure* rather than simply *welding procedure*, since the procedure refers only to welding a particular joint and does not encompass such items as the sequence of welding the various joints in a structure.

Table II—Summary of Base Metal Types, Compositions and Heat Treatments*

Base Metal Reference Designation	Type	Specification No	Manufacturer	Chemical Composition Range, %									Heat Treatment	
				C	Mn	Si	S	P	Cr	Ni	Mo	V	Quench	Temper
I	Rolled	XYZ	"X"	0.26 0.30	0.95 1.15	0.60 0.90	0.035 max.	0.035 max.	0.60 0.70	.. ..	0.20 0.25	.. ..	1650° F., water	800° F., 2 hr.
II	Rolled	QRS	"Y"	0.23 0.30	0.85 1.00	0.20 0.30	0.04 max.	0.03 max.	0.75 0.90	0.90 1.10	0.30 0.35	.. ..	1575° F., water	600° F., 4 hr.
III	Cast	TUV	"Z"	0.21 0.31	1.30 1.80	0.25 0.75	0.05 max.	0.05 max.	0.20 0.70	.. ..	0.25 0.45	.. ..	1600° F., water	1100° F., 2 hr.

* The data shown in this table are purely fictitious and intended simply to illustrate how the table might be filled in.

Table III—Summary of Electrodes and Welding Currents and Voltages*

A. Electrodes Conforming with Specification ABC-123:

Electrode Reference Designation	Manufacturer	Brand Name	Grade	Type	Class
A	"X"	Bestweld	V	1	1
B	"X"	Superweld	VI	1	1
C	"Y"	Bestalloy	VI	1	1
D	"Y"	Superloy	VI	3	2
E	"Z"	Bestarc	V	1	1
F	"Z"	Superarc	VI	1	1

B. Electrodes Not Conforming with Specification ABC-123:

Electrode Reference Designation	Manufacturer	Brand Name	Type of Coating		Chemical Composition Range, % C	Mn	Si	S	P	Cr	Ni	Mo	V	Others
G	"Q"	Excelweld	Lime	Core wire	0.15 max.	3.50 4.50	0.25 0.60	0.03 max.	0.04 max.	19.5 21.5	9.0 10.5	.. ..	.. ..	.. ..
				Deposited weld metal	0.17 max.	3.00 4.50	0.80 max.	.. ..	.. ..	18.0 20.5	.. ..	0.50 1.00	.. ..	.. ..
H	"R"	Wonderweld	Titania	Core wire	0.15 max.	1.50 2.00	0.25 0.60	0.03 max.	0.04 max.	19.5 21.5	9.0 10.5	.. ..	.. ..	.. ..
				Deposited weld metal	0.17 max.	1.25 2.00	0.80 max.	.. ..	.. ..	18.0 20.5	.. ..	1.80 2.25	.. ..	.. ..

C. Ranges of Current and Voltage to Be Used with Each Size Electrode:

Diam. of Electrode	Current Range, Amp. Flat Position	Vertical Position	Horizontal Position	Overhead Position	Voltage Range Flat Position	Vertical Position	Horizontal Position	Overhead Position
5/32	85–115	75–100	80–105	75–100	21–28	20–26	20–26	20–26
3/16	150–185	135–165	145–175	135–165	23–29	22–27	22–27	22–27
1/4	200–245	.....	190–230	.....	24–30	...	23–28	...
5/16	310–340	.....	.....	.....	25–32	...	...	...

* The data shown in this table are purely fictitious and intended simply to illustrate how the table might be filled in.

mum number of tests required to qualify all welding on the structure.

5. It provides space for recording the results of procedure qualification tests.

6. It indicates whether a given procedure has been qualified, whether that procedure has been qualified in more than one position of welding, and provides supporting evidence by indicating exactly what test plates effected the qualification.

Tables II and III illustrate two other forms that have been found useful in connection with this system. The use of these tables will make it possible to simplify the welding procedure form illustrated in Fig. 4, since the detailed information on base metal composition and heat treatment, types of electrodes and welding current and arc voltage ranges can be indicated simply by reference to a table. Figure 6 illustrates how the form illustrated in Fig. 4 will appear after these simplifying modifications. It will be noted that brief references to Tables II and III replace the detailed description of the base metal, the designation of the welding electrodes and the listing of the welding current and arc voltage for each pass. The value of this simplification will be evident when it is considered that this form is filled out for each of the dozen or more different joints in a given assembly or subassembly.

When the system outlined above is employed in preparing a complete set of welding procedures for a given structure, the following steps are carried out in the order indicated:

1. Prepare an isometric or perspective drawing of the complete structure or subassembly showing the locations of the welded joints (Fig. 5).

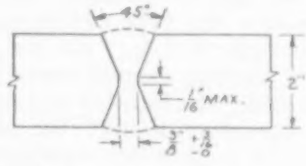
2. Prepare a chart assigning a welding procedure number to each joint and providing spaces for indicating the status of procedure qualification (Table I).

3. Prepare a chart indicating the pertinent data for each kind of base metal incorporated in the structure (Table II).

Welding Procedure No. 1

Joint A-A

Details of Joint:



Welding Procedure – General:

Base Metal (reference designation) 1

Electrode (reference designation) B, C OR F

Power Source (AC or DC) and Polarity if DC D.C., REVERSED

Welding Current & Arc Voltage Range AS STATED IN TABLE III

Use of Spatter Compound on Scarfed Edges NONE

Backing COPPER

Preheating NONE

Position of Welding FLAT

Postheating NONE

Details of Welding Procedure:

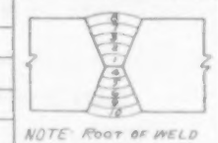
Pass No.	Electrode Size	Type of Pass	Location & Sequence of Passes
1	5/16	BEADING	
2, 3	1/4	WEAVING	
4	5/16	BEADING	
5, 6	1/4	WEAVING	
7 to 10	5/16	WEAVING	NOTE: ROOT OF WELD SHALL BE GROUND TO SOUND METAL BEFORE DEPOSITING PASS No 4.

Fig. 6—Simplified Version of Form Used for Recording Welding Procedures

Compare this form, which utilizes the charts illustrated in Tables II and III, with the form shown in Fig. 4. (Note: The data shown on this form are purely fictitious and intended simply to illustrate how the form might be filled in.)

4. Prepare a chart indicating the pertinent data for each brand of electrode to be used in fabricating the structure (Table III).

5. Record the welding procedure to be used in welding each joint, utilizing the form illustrated in Fig. 6.

6. Determine, by reference to the applicable code or specification, the minimum number of tests required to qualify all of the welding procedures to be used on the structure.

7. Conduct the required procedure qualification tests.

8. Record the results of the procedure qualification tests in the appropriate spaces of the chart mentioned in step 2 (Table I).

Adaptability to Commercial Non-Ordnance Welding

The forms and tables here presented have been explained in detail because of their possible usefulness in commercial non-Ordnance welding. This is particularly true in the case of welding being performed under the requirements of a code or other regulations, such as a municipal building code, the A.S.M.E. Unfired Pressure Vessel Code, or the Rules for Building and Classing Steel Vessels of the American Bureau of Shipping. Since the forms are easily reproducible, copies may be obtained for all who will have use for them. One copy can be used by the welding shop as a job sheet. Another copy can be used by the inspector on the job as a check list to verify that the welding procedures actually in use correspond to those that have previously been qualified. Still other copies will be required as part of the contractor's permanent records for future reference, and for the records of the inspection agency in the event that the fabrication and the inspection are not performed by the same organization.

Emergency Repair of Magnesium Parts by Gas Welding*

MAGNESIUM parts which have broken or cracked usually can be sufficiently repaired by gas welding to enable the part to be placed back into use. Generally speaking such repair should be considered only as a temporary measure until a replacement part can be obtained. This is particularly true in the case of repairs made on magnesium castings. The emergency welding of magnesium parts often requires deviation from normal practice in order that the parts may be placed back into service quickly. Examples of such deviation are: The use of multiple bead welds, the welding of sections that are impossible to thoroughly clean, the welding of cast metal, and inadequate cleaning of welds due to lack of facilities.

Materials and Equipment

Table 1 serves as a guide to the selection and regulation of welding equipment when using oxyacetylene gas. The welding of heavy sections may sometimes require the use of tip orifice diameters larger than the maximum of 0.059 in. specified in the table.

* Magnesium Division, The Dow Chemical Company, Midland, Michigan

Table 1—Guide to Selection and Regulation of Oxyacetylene Welding Equipment

Metal Thickness, Inches	Welding Rod Diameter, Inches	Tip Orifice Diameter		Oxygen Pressure Lb. per Sq. In.	Acetylene Pressure, Lb. per Sq. In.
		Inches	Drill No.		
0.020	1/16–3/32	0.035	65	1 to 4	1 to 3
0.032	1/16–3/32	0.035	65	3 to 5	1 to 3
0.040	3/32–1/8	0.035	65	3 to 5	1 to 3
0.051	3/32–1/8	0.035	65	3 to 5	1 to 3
0.064	3/32–1/8	0.040	60	3 to 5	3 to 5
0.072	3/32–1/8	0.040	60	3 to 5	3 to 5
0.081	3/32–1/8	0.046	56	3 to 5	3 to 5
0.091	1/8 –5/32	0.046	56	3 to 5	3 to 5
0.128	1/8 –5/32	0.059	53	3 to 5	3 to 5

Torch: An ordinary oxyacetylene torch can be used. Tips with orifice diameters ranging from 0.035 in. to about 0.081 in. should be on hand.

Welding Rod: Magnesium alloy welding rod is used and it should be of the same composition as the material being welded. If rod of the same composition is not available, a rod of a different magnesium alloy slightly lower in melting point may be substituted. If standard welding rod is not available it is possible to use strips cut from sheet, extrusions or castings. Such strips should be thoroughly cleaned immediately before use with steel wool, emery cloth or by scraping. Extruded welding rod is available in convenient 36 in. lengths in a variety of alloys and diameters as listed in Table 2. A convenient color identification is used to distinguish rods of different compositions.

Table 2—Magnesium Alloy Welding Rod*

Dowmetal Alloy	Melting Point, ° F.	Color Identification
C	1110	Yellow and red
FS-1	1160	Blue and green
H	1135	Green and black
J-1	1145	Yellow and green
M	1200	Yellow
O-1	1130	Green and purple

* Rod diameters—inches 1/16, 3/32, 1/8, 5/32, 3/16, 1/4.

Welding Flux: A welding flux must be used to prevent oxidation of the metal during the oxyacetylene welding of magnesium. Dow 450 and 460 welding fluxes are especially recommended for this purpose. If these materials are not available, satisfactory repair welds can be made with most aluminum welding fluxes.

Dow fluxes for magnesium are supplied as a dry powder which is prepared for use by mixing two parts of the powder with one part of water. After opening a bottle of flux, it should be kept tightly closed because welding fluxes for magnesium are hygroscopic and will take on moisture. The mixing of the flux and water paste should be done in glass containers which should be kept covered when not in use. Metal containers are not recommended because of the chances for contamination of the flux.

Operator's Equipment: Welders working with magnesium alloys should wear gloves and the usual type of welding goggles. Blue glass gives best visibility during welding.

Field Repair of Magnesium Castings

The first step in making a repair on a magnesium casting is to clean the casting thoroughly from grease, oil, dirt, chemical coatings, paint and the like. This can be done by the use of alkaline cleaners, carbon tetrachloride, gasoline or soap and water.

After cleaning, the immediate area in which the repair is to be made must be prepared. The edges of the hole, crack or other type of defect must be dressed down to clean, sound metal. This may be accomplished by routing, filing, chipping, scraping, or similar means. The slope of the sides of the defect should be about 45°. If a defect penetrates the wall of the casting, a land or root face of about $^1/_{16}$ in. should be left on the bottom side. The surface of the casting around the zone to be repaired should also be scraped, sanded, filed or wire brushed, to be certain that all oxide, paint or other coatings are removed.

The first step in the welding operation is to apply the flux paste with a small brush to the edges of the area to be welded. Before starting to weld, the torch should be adjusted to a neutral or slightly reducing (carburizing) flame. The torch should be adjusted to a $^1/_4$ in. inner cone or until such inner cone slightly "feathers" at the tip when the oxygen pressure is lowered.

The casting to be welded should be preheated with the torch or in a furnace before actual welding is started. The entire casting should be brought up to a preheat temperature of about 650° F. A mark made on the casting with ordinary blue carpenter's chalk will turn white when a temperature of approximately 600° F. is reached. Actual welding is started by slowly preheating a small area with a fanning action of the welding flame. As the metal begins to melt, the welding rod is dipped into the molten puddle and then withdrawn as sufficient molten metal is obtained. The rod is held in the outer flame and is dipped into the puddle intermittently, the torch being moved forward as rapidly as possible. The flame should be moved forward in a straight line, the torch being inclined at about 45° to the work. All welds should be made in a one continuous pass if possible, since this keeps the surrounding metal up to temperature. If insufficient heating is being maintained, as indicated by cracking, a larger tip size is indicated.

After welding is completed, the casting should be placed in a furnace for one hour at about 650° F. If no furnace is available, a gas flame can be played over the entire casting to bring it up to a temperature of about 650° F., after which the casting should be allowed to cool slowly away from drafts.

When the repaired casting is cool enough to handle with the bare hands, all excess flux should be removed by thorough scrubbing with a stiff bristle brush and plenty of hot water.

Welding of Castings to Wrought Parts

When magnesium fittings or castings are gas welded to sheet or extrusions, the edges of heavy cast sections should be tapered or beveled down to the thickness of the sheet or extrusion. If such sheet or extrusion exceeds $^1/_8$ in. in thickness, it likewise should be dressed down. The casting should be thoroughly preheated with a torch or in a furnace to about 650° F. before starting to weld. During the actual welding operation, the welding flame should be directed principally upon the casting.

Field Repair of Wrought Magnesium

The repair of wrought magnesium parts by gas welding does not require preheating. Otherwise the procedure is the same as recommended for the gas welding of castings.

Cleaning and Painting

Gas welds should be cleaned immediately after completion by scrubbing with a stiff bristle brush and plenty of hot water. Next they should be immersed for 1 minute in a "Chrome-Pickle" solution consisting of $1^1/_2$ pints of nitric acid and $1^1/_2$ pounds of sodium dichromate ($Na_2Cr_2O_7 \cdot 2H_2O$) plus enough water to make one gallon of solution. After thorough rinsing and drying, parts should be painted. In the case of emergency repair jobs, the ingredients for making the "Chrome-Pickle" bath may not be available. When such is the case, gas welded parts should be painted immediately after scrubbing with the brush and hot water.

(Continued from page 1045)

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Welding of LST's at Seneca, Ill.

By L. C. Stiles*

THE Shipbuilding Division of the Chicago Bridge & Iron Co. has recently completed and delivered to the Bureau of Ships, Navy Dept., its 157th and last LST (Landing Ship Tank) called for on the Seneca shipbuilding program. Some of the methods employed there may be of interest to others in the shipbuilding industry and to anyone concerned with the construction of large welded structures, as they might be profitably applied to other work of comparable size.

To better understand the welding problem, it seems advisable to briefly describe the ship and the facilities at Seneca for its construction.

The LST

The LST is an ocean-going, Diesel-powered ship 327 ft. long, has a 50-ft. beam and is 3 decks high. It has a flat bottom and shallow draft. Under normal loading the bow end draws about 7 ft. less water than the stern to facilitate landings on beaches. The bow is equipped with hinged doors which swing horizontally. Just behind the doors is a ramp which is hinged at the bottom and which can be lowered when the bow doors are open. Over this ramp, tanks or other vehicles can be driven under their own power from the ship's cargo space, which is 30 ft. wide and about 200 ft. long, to a beach. A second ramp, hinged at the main deck level, can be lowered to connect with the upper end of the bow ramp which makes it possible to also drive vehicles carried on the main deck directly to a beach. This arrangement permits unloading in a minimum length of time which, during an invasion, is of utmost importance. Approximately 1200 tons of steel plates and structural shapes went into each ship. Three-eights-inch plate was used in the bottom and sides except at the bow end and in the bilge course where slightly heavier plates were used. Decks, bulkheads and the superstructure were $^5/_{16}$-, $^1/_4$- and $^3/_{16}$-in. plates. Double lap-welded joints were used throughout in the plate work except in the heavier plating in the bow end and in the bilge course where single-V butt joints were used. Roughly 60,000 lb. of welding electrodes were used per ship at Seneca. Several thousand additional pounds per ship were used in our fabricating plants on preassemblies.

* The author was the Hull Welding Superintendent on this project. He is presently the welding engineer at the company's Birmingham, Ala. plant.

The Shipyard

The shipyard at Seneca (Fig. 1) occupies a 192-acre tract of flat land on the north bank of the Illinois River 70 miles southwest of Chicago. The site was previously pasture land with a thin layer of top soil over solid sandstone. The top soil was removed leaving a surface of sandstone on which foundations, roads and railroads were built at very low cost. Because of this fine site, it was possible to spread the work out over a much larger area than is possible in the average shipyard with the result that much of the usual congestion, and consequent loss of efficiency, was avoided. You will note in Fig. 1 that there were 3 parallel rows of ships under construction. There were 8 building berths on the east or near side of the yard and 7 on the west or far side of the yard. The middle row consisted of 15 transfer berths, 5 of which were occupied by ships at the time this picture was taken. The hulls were completely fitted and welded on the two side rows of building berths. When each hull was completed, it was picked up on 16 special cars (Fig. 2) and moved to the middle row of transfer berths.

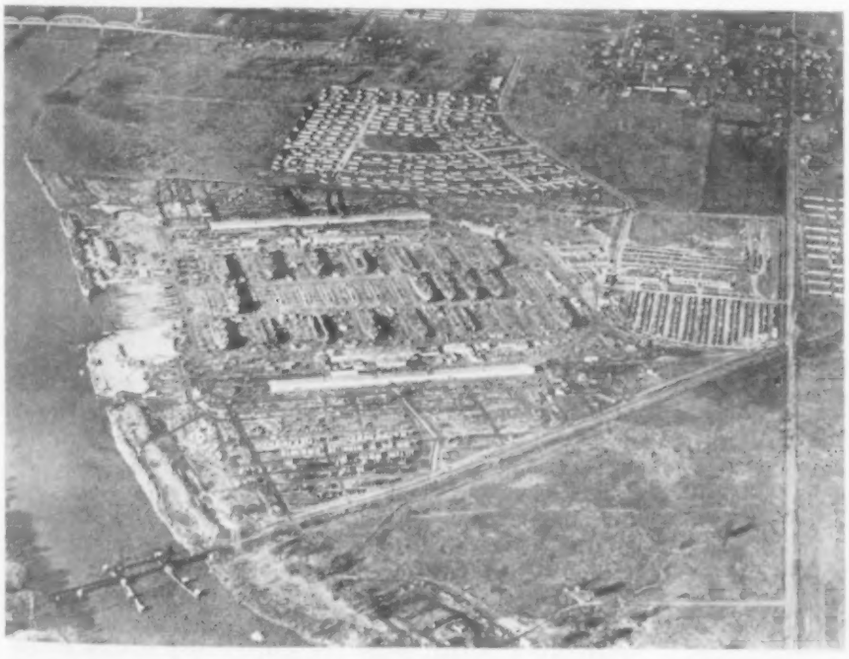

Fig. 1—This View of the Seneca Yard Was Made in February 1945, at Which Time There Were Still Ships Under Construction on All 15 Construction Berths. Five Ships Were on Transfer Berths and 3 Tied Up to the Dock

Readers interested in heavy rigging may be interested in these cars and may be curious to know how such a load could be equally divided among 16 cars. These cars were designed to carry 100 tons each. The platforms are movable vertically and may be raised or lowered by means of a hydraulic jack built into each car between the frame of the car and the

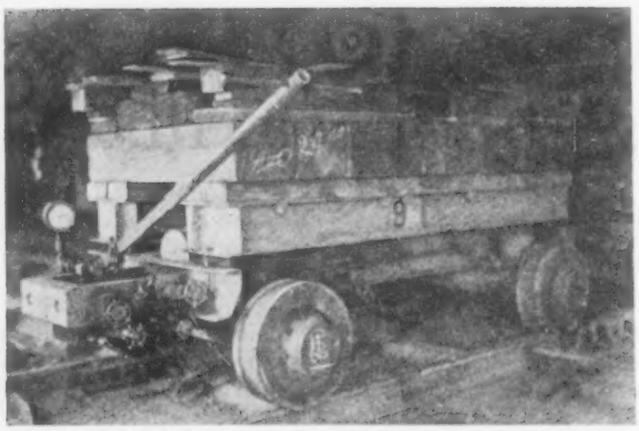

Fig. 2—One of 16 Cars Used to Transfer Ships from Building Berths to the Launching Ways. The Capacity of Each Car Is 100 Tons

platform. A pressure gauge was connected to the oil cylinder and indicated the load on the car at all times. While a ship was being moved, one man walked along beside each car watching the gauge and raised or lowered the jack to maintain the desired pressure as his car passed over an uneven section of railroad track. Moving a ship from a side building berth to a center transfer berth, a distance of 400 ft., required only 15 min. and was always scheduled during a lunch period.

The installation of piping, mechanical and electrical equipment, insulation and outfitting items was started while the ships were on the side building berths, but the bulk of this work was done while they were in the center row of transfer berths. As the work progressed, each ship was from time to time moved along the row of transfer berths toward the single set of launching ways at the edge of the river. At the time of launching, each ship was 90% complete. After launching, the ship was tied up at the dock in the wet basin where the last 10% of the work was completed, which consisted chiefly of loading aboard the last of the outfitting items, fuel oil, fresh water and provisions, conducting dock trials, making final adjustments and touching up the paint. Each ship was commissioned and turned over to a Navy crew who departed with it down the Illinois River toward the Mississippi, New Orleans and the Gulf of Mexico.

Fig. 3—Typical Shop Preassemblies Arriving in Seneca from Our Fabricating Plants at Chicago, Ill., Birmingham, Ala., and Greenville, Pa.

The original contract was for 40 ships, to be delivered during the 1943 calendar year at the rate of 1 per month on the first 2, 3 per month on the next 6, then at the rate of 1 per week for the balance of the contract. Delivery schedules on succeeding contracts were gradually stepped up until a rate of 7 ships per month was reached where the schedule leveled off. All ships were delivered on or before the scheduled delivery dates.

The Task System

There had never been any shipbuilding and but little heavy construction work in the Seneca area. Therefore, the available labor in the vicinity was very inexperienced in the work to be done. There were farmers, coal miners, glass workers, automobile mechanics, housewives and even preachers hired to help build ships who had to be trained. Since it would take too long to train enough all-around mechanics in each craft to complete the ships within the allowed time, individuals were picked and trained to do one small part of the work done by any particular craft. This was similar to the practice followed by the automobile industry on assembly lines. The difference was that since the ships could not be moved to the man, the man moved from ship to ship. From 10 to 15 such individuals were grouped together into a crew under a subforeman. Enough work, which was called a

Fig. 4—Shop Preassembled Box Sections in Storage Yard at Seneca

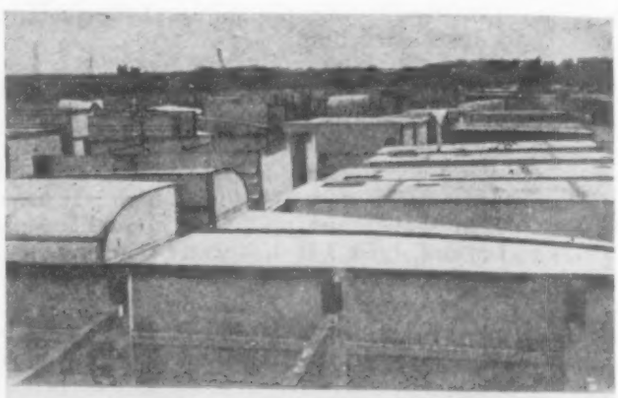

Fig. 5—Lower Bow Preassembly in Foreground. In the Upper Right-Hand Corner May Be Seen Two Upper Bow Preassemblies

Fig. 6—Lower Stern Preassembly with 3rd Deck and Framing in Place. All Down-Hand and Vertical Welds Were Made at This Stage, Before the Skin Plates Were Fitted

Fig. 7—View of Lower Stern with Fitting of Skin Plates Under Way. Fitting Devices Are in Evidence in This View

task, was assigned to each crew to keep it busy for one building period on one ship and the same work was reassigned to each crew on every ship. The length of time covered by one building period varied from 1 wk., when 1 ship per week was being built, down to $3^1/_2$ days, when 7 ships per month were being built. Thus, a green worker was quickly taught to do a particular job, or task, on every ship as a part of a particular crew. He and his subforeman knew just how much time they had to complete that job. To avoid the possibility of several crews trying to work in one compartment at the same time, the total time which was scheduled to elapse between the laying of the keel and commissioning was divided up into 20 work periods, and one of these periods was assigned to the crew as the definite time during which it was expected to do its work. By careful scheduling, it was generally possible to avoid working more than one crew in any compartment at any one time.

As an example of how this system was applied to the welding, one crew, consisting of a subforeman, 10 welders, 2 chippers and 2 welder helpers, was assigned to weld the deck house on every ship and allowed the eleventh building period on every ship in which to do it. After welding several deck houses, this crew had memorized the welding sequence, type and size of rod for each weld, weld sizes and how to best place their bodies to make obstructed welds. Other crews assigned to the welding of other parts of the ship became especially proficient

Fig. 8—Lower Stern Preassembly with Skin Plates Fitted Ready for Welding

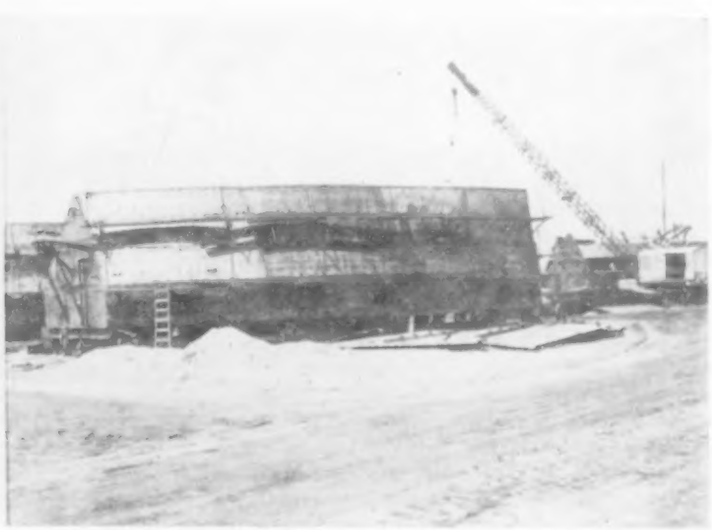

Fig. 9—Upper Stern Preassembly Setting Upside Down on Jig. The Down-Hand and Vertical Welds Were Made While the Unit Was on the Jig. After This Section Was Turned Right Side Up and Fitted to the Ship, the Balance of the Welding Was Completed

Fig. 10—Bottom Plates with Longitudinal Angles and Transverse Frames Attached Setting on a Building Berth

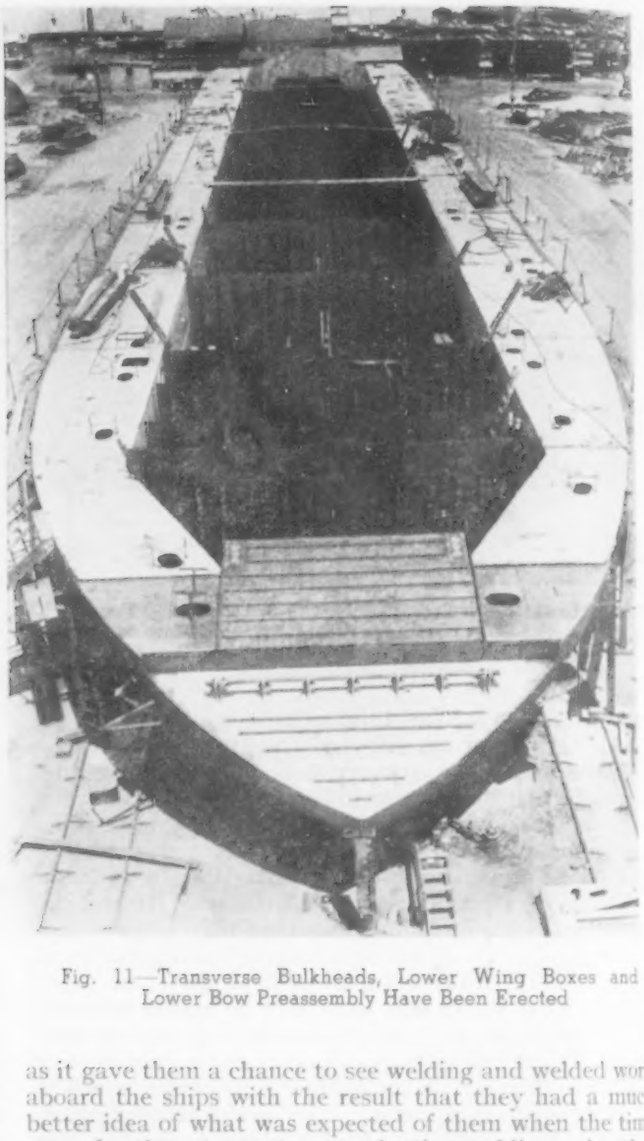

Fig. 11—Transverse Bulkheads, Lower Wing Boxes and Lower Bow Preassembly Have Been Erected

in their particular jobs. The value of this plan was demonstrated on several occasions when it became necessary to temporarily assign a crew to work in some other part of the ship which was new to them. Production invariably dropped off from 10 to 15%. In the case of crews permanently assigned to new work, from 2 to 4 wk. were required for them to learn the new job well enough to produce at a normal rate.

Training Welders

When the yard was started, the company transferred a number of field welders to Seneca, most of whom were used as instructors or supervisors. In addition, a number of skilled welders were hired at the gate. Eighty per cent of the welders eventually used in the yard, however, had to be trained. To do this, welding schools were set up in several nearby towns, as well as in the shipyard. The outside schools, in general, gave students a fair knowledge of the fundamentals of welding, but very few were able to pass the Navy welders' qualification test at the end of their course of training. The students were then hired at the shipyard either as tack welders or as student welders. In the early days of the yard, students who could pass the test were put on production work immediately and given considerable more instruction by the subforemen over the welding crews. When the shortage of welders eased slightly, students were required to tack for at least 2 mo. before going on production welding. Tacking helped the students tremendously as it gave them a chance to see welding and welded work aboard the ships with the result that they had a much better idea of what was expected of them when the time came for them to start on production welding. Another advantage was that while tacking, they gained some knowledge of fitting. Those who had tacking experience generally exercised better judgment than those who didn't have that experience whenever it was necessary for them to decide whether a given seam was or was not properly fitted for welding.

It is generally assumed that the new crop of wartime shipyard welders learned the trade in welding schools. It is true that most of them were taught the fundamentals of welding in the schools and they did learn to make passable test plates under the most favorable conditions. To give this partial training to so many in so short a time was a real accomplishment and much credit is due to the schools and instructors in them. At Seneca, the subforemen over the welding crews, all of whom were themselves first-class welders, took over the task of completing the training of the student welders as soon as their formal schooling was completed. It was their duty to make finished welders out of the student welders. Approximately 25% of the average welder's instructions were received while in one or more of the welding schools. The other 75% was received from the welding subforemen while on production work. We feel sure that the additional instruction given our student welders by our welding supervisors definitely speeded up the development of highly skilled welders which, in turn, contributed greatly to the general quality of the welding which went into the ships built at Seneca.

Fig. 12—The Upper Box Sections Have Been Erected. The Upper Bow Preassembly Sets on the Ground Ready to Be Turned Right Side Up and Set in Place on the Ship

The Incentive System

The Chicago Bridge & Iron Co. has for many years believed in paying for production work on an incentive basis. Before the introduction of arc welding, work on riveted structures was paid for on a piecework basis. Since welding was first introduced, it has been paid for also on a similar basis. During the course of years, piecework rates have been developed which were applied to the welding at Seneca. The advantages of piecework welding on this work were as follows:

1. Approximately one-half as many welder manhours were required to weld an LST at Senca as were required to weld an LST at other yards where the welders were paid on an hourly basis.

2. Since the average piecework welder produced twice as much as the average day work welder, only half as much welding equipment was needed for the work.

3. A more ambitious type of worker was attracted to the welding because of the possibility of higher than average earnings, depending upon his skill and speed. As a group, the piecework welders were the hardest working craftsmen in the yard.

4. A higher standard of quality could be and was demanded of the piecework welders.

5. Weld sizes were kept closer to the required sizes, which tended to minimize residual stresses, the waste of welding rod, electric power and time which results from making oversized welds.

6. Welders on piecework were more willing to use the largest size electrodes possible for a given weld than were welders who were paid on an hourly rate. This avoided much wasted time due to the use of smaller rod than necessary. Various sizes of rod were used in the following proportions:

$\frac{1}{4}$ in.—25%
$\frac{7}{32}$ in.— 4%
$\frac{3}{16}$ in.—47%
$\frac{5}{32}$ in.—22%
$\frac{1}{8}$ in.— 2%

There were certain disadvantages of piecework which, even though they did not begin to equal the advantages

Fig. 13—Here the Upper Bow, Bow Ramp and Bow Doors Have Been Fitted. Notice the Simple Scaffolds. This Was the Standard Type Used for Practically All Scaffolds on the Outside of All Ships

Fig. 14—Bow End with Bow Doors Open. The Lower End of the Upper Ramp Leading to the Main Deck and the Upper End of the Lower Ramp May Be Seen in This View

on this work, should be mentioned. They were as follows:

1. Most piecework welders were inclined to cut down on weld sizes and to use more heat than they could properly handle. Close inspection by the supervisors was necessary. Faulty work was repaired by the welder who did it with no pay allowed for the repairs. Welders soon learned they could earn more by doing their work right the first time.
2. The accounting problem was considerably greater when working piecework. It was necessary to keep very detailed records of all work performed. To avoid arguments, pieceworkers had to be paid to the penny exactly what they earned.

Inspection

Under piecework disadvantage No. 1, attention is called to the necessity of close inspection. In addition to the usual visual inspection, $1^1/_8$-in. diameter circular plugs were periodically cut from each welder's work by the trepanning method. These plugs, containing a section of weld, were deep-etched by boiling in a 50% hydrochloric acid solution for 30 min. and then examined for faults such as slag or gas inclusions, incomplete fusion, cracks or any other defect that could not be seen on the surface. Also, throat thicknesses of lap and fillet welds were checked. For instance, many arguments regarding the size of lap welds were quickly settled by cutting a plug from the weld in question and measuring the throat. Welds found to contain bad defects had additional plugs cut from them to determine the length of the defect and were chipped out and rewelded. A record of all plugs cut from each welder's work was kept and each welder was rated according to his percentage of good plugs. If his rating fell below 75%, he was either demoted to tacking or sent back to school for further instruction and a retest. Each plug cut was shown to the welder who made the weld from which it was removed, and to his subforeman who was also held responsible for the quality of the work. The welders and the subforemen were extremely interested in their plugs and unquestionably learned much by examining them. Every few months a list of all welders showing their plug ratings was printed and distributed. Welders with high ratings bragged about their ability and were careful to maintain their high rating. Those with low ratings generally worked harder to improve their ratings before the next list was distributed. This method of inspection has been used by the company with considerable success for the past 10 yr.

Preassemblies

The hull material was fabricated, preassembled and welded into sections as large as could be shipped by rail in our plants located at Chicago, Ill., Birmingham, Ala., and Greenville, Pa. Each plant was assigned a certain portion of the ship, built the necessary jigs and specialized in the production of its particular part. (Figs. 3 and 4.)

Many larger preassemblies, which could not be shipped by rail, were made at Seneca. Bottom, third deck and main deck sections measuring 24 x 30 ft. were assembled on jigs, the structural stiffeners attached and welded on the top side. They were then turned over and welded on the other side. This permitted doing 90% of the welding on these sections in the down-hand position using $^1/_4$-in. diameter electrodes, the largest diameter allowed by the specifications. The other 10% of the welding in these sections was in vertical connections in the structural members and was welded with $^3/_{16}$-in. diameter rod. Figures 5 to 9 show bow and stern preassemblies. You will notice that all bow and stern section views show them setting on the jigs upside down. While in this position all of the down-hand seams were welded, to avoid welding them overhead after the sections were set right side up on the ship. Vertical seams in preassemblies were, with few exceptions, welded while the units were still on the jigs. The balance of the welding on each section was left to be completed after the sections were set in place and fitted to the rest of the ship. By this procedure, the amount of slow, expensive, overhead welding was kept to a minimum.

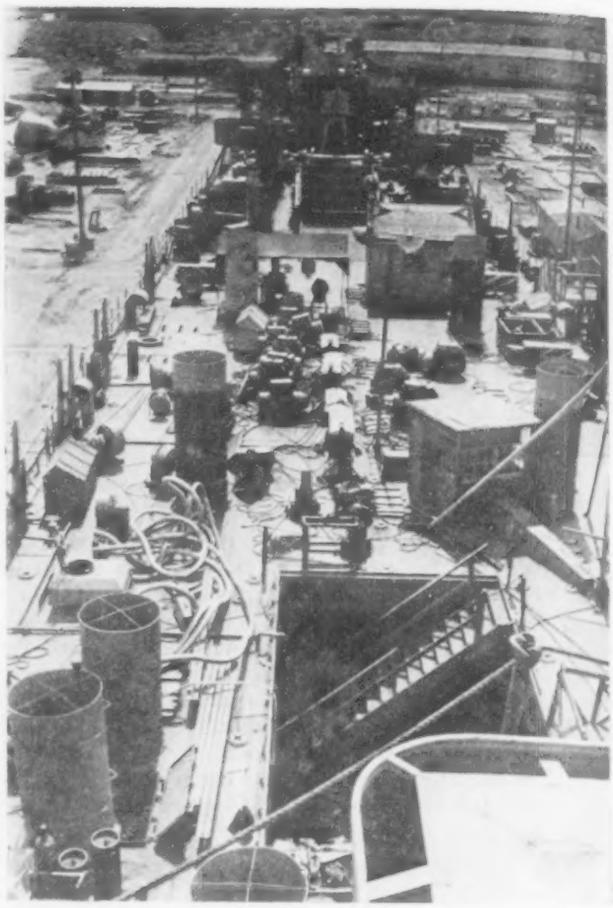

Fig. 15—Main Deck Looking Forward from Navigating Bridge. Notice Welding and Ventilating Equipment in the Foreground and Central Portion of This Picture

Welding Procedures

Figures 10 to 18 show the progress of the construction from the laying of the keel to the launching. A general idea of the methods used can be had by examining these views.

The welding procedures for the various parts of the ship were worked out and sketches were made showing the joints to be welded in a given section. By means of numbers placed on the joints, the sequence of welding was clearly indicated. The joint marked 1 was welded first, the one marked 2 was welded second, etc., in numerical order. In the early days of the first few ships which were built on a comparatively slow schedule it was possible to follow a rather conventional procedure. The 30- x 24-ft. bottom sections were laid on a building berth and welded together. The keel beams were set

Fig. 16—Aft End of Main Deck, Deck House and Pilot House. Anti-aircraft Gun Emplacements Are Very Much in Evidence. Several Other Ships at Various Stages of Construction Appear in the Background

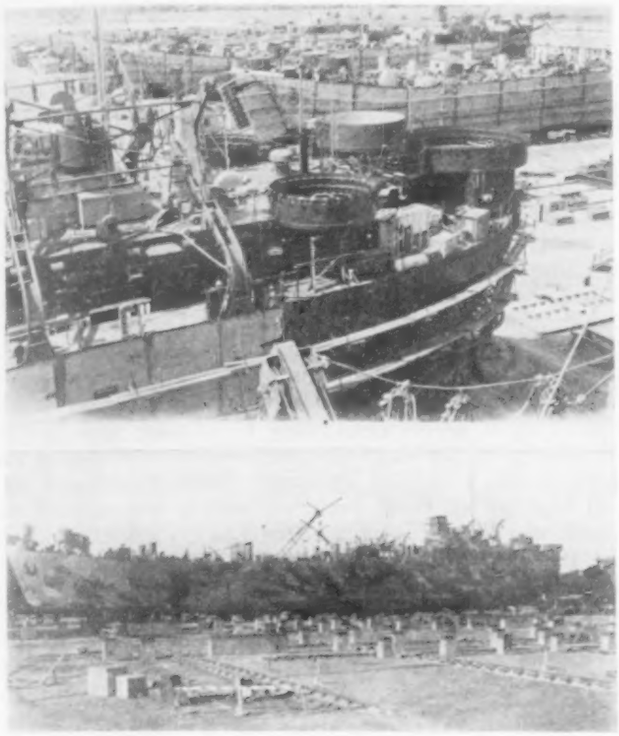

Fig. 17—This Ship Was 85% Complete When This Picture Was Taken. A Week Later, It Was Launched

up, welded together, then tacked to the bottom. The keel was then welded to the bottom, starting at midship and working forward and aft. These welds were back-stepped, as were all welds a foot or more in length throughout the ship. The welding on each side of the keel was kept nearly even to prevent drawing the keel beam out of line. The center compartment bulkheads were set up and welded to the bottom, starting at the keel and back stepping outboard. The lower box sections were then welded together and to the bottom plating starting at midship and working forward and aft. The third deck and supporting structural work was then welded together and to the side box sections with the welding progressing from the middle of the ship both forward and aft. Then the preassembled lower bow and lower stern sections were welded to their respective ends which completed the ship up to the third deck level. The third deck to main deck box sections and main deck sections were then welded together and to the third deck starting at midship and working forward and aft. After this, the upper bow and stern sections were welded, to complete the bulk of the hull welding up to the main deck level. This procedure was considered good and entirely safe, but too slow to satisfy the demands for the delivery of LST's at faster and faster rates.

Everyone familiar with steel fitting knows that considerable force is usually used in fitting. They have seen tack welds break in completely fitted joints when too much force is used in fitting nearby seams. The reason for the failure of the tack welds is obvious. More stresses were being set up in the structure by the use of force in fitting than the tack welds could carry, so the tacks broke. So far as residual stresses are concerned, there is no cause to worry because the tack welds are expected to develop only a small percentage of the ultimate strength of the completely welded joint. The usual procedure is to refit the seam, making a small adjustment in the dimensions between the parts if necessary and retack it making the tacks a little heavier. Likewise everyone has seen buckles appear in plate areas and bows come into structural members while fitting is in progress and before the welding is even started. Since the welding had not been started, these deformities could not be the result of welding stresses. They must be the result of fitting stresses. Such deformities are usually easily corrected by cutting open all or parts of nearby joints, adjusting dimensions across these joints until the buckle or bow disappears, and retacking those joints.

Because of the urgent need for speed, it was decided to deviate from the practice of completing the welding in each section before starting the welding in the adjoining section, as that practice seriously limited the number of welders that could work on a given ship at any particular time. After the bottom, keel and engine bases were welded, the crews assigned to lower wing boxes, third deck sections and lower bows and sterns were moved onto the ship. Each crew immediately proceeded with the welding of its regularly assigned section, even though the adjoining section had not been welded. Before the welding below the third deck was completed, the crews assigned to the various sections between the third deck and main deck were moved onto the ship and the welding of their regularly assigned sections got under way. In this manner, it was possible to be welding many sections of the ship simultaneously, which, in turn, made it possible to use more welders per ship. Naturally, by using more welders, each ship was welded in a shorter period of time. It was reasoned that it was safe to do this because the tack-welded seams between the various scattered sections being welded could be watched and would give warning of mounting residual stresses which might become dangerous. The tack welds, plate areas and structural members were under constant watch for signs of distress which would show up in the form of broken tacks, buckles in the plate area or in the bowing of structural members. If none of these adverse results were observed, the residual stresses were assumed to be no more severe than the usual residual stresses ordinarily set up by the fitting, which were considered to be tolerable. In

Fig. 18—LST 1150. Waterborne After Launching. At This Stage, It Was 90% Complete

a very few instances, tacks were broken or deformation resulted. This usually necessitated some readjustment of joint dimensions before retacking. In some cases it was necessary to cut loose seams already welded to relieve the stresses causing buckles in the plate or bows in structural members. The welding sequence of course was immediately changed to avoid a recurrence of the difficulty.

Cold Weather Welding

It is generally agreed that welding during cold weather is not desirable. The danger of cracks occurring in the plate or in the welds is considerably greater. Here again, in the interest of speed, it was decided to deviate from the generally accepted good practice of stopping the welding at low atmospheric temperatures. At first, welding was stopped at 10° F. Then it was decided to continue down to zero. Last winter the lower limit was removed and the ability of the welders to endure the cold determined the temperature at which welding stopped. The result was, the welding continued on days when the temperature went to 12 and 14° below zero, but stopped on one day when it went to 16° below the zero mark. When the temperature was below freezing, local preheating at the starting point was customary, bringing the temperature of the steel up to something above 32°, after which the heat of welding was depended upon to preheat the steel immediately ahead of the arc. An exception was made in the welding of the main and auxiliary engine bases and skegs. General preheating and the continuous application of heat to keep the steel well above freezing was found necessary, because of the thicker steel to be welded and the greater rigidity of these parts. It was found desirable to preheat armor plate to 100° F., or until it felt warm to the bare hand.

Cracks from welding in cold weather were expected and were constantly watched for. Surprisingly few were discovered. All were short and none was of serious consequence. It was observed that most of them occurred in the plate close to heavy welds which were the result of either poor design or of the welder putting on excessive weld metal. It was further observed that about 75% of the cracks were discovered within 48 hr. after the welding in the vicinity of the crack had been completed. About 99% were discovered within the first week and all of them were found within from 4 to 6 wk. after welding, if we assume no more were discovered after the ships left the yard. No cracks in any of the ships built at Seneca have ever been reported to the company, so this assumption seems to be reasonable. There is no way of determining exactly how much time elapsed between any actual break and its discovery, unless there was a report which was heard. Very few were ever heard. Therefore, it seems reasonable to assume that 75% of the cracks in the ships occurred within a period of less than 48 hr., that 99% occurred within less than 1 wk., and that all of them occurred within less than 6 wk. These observations might be used as evidence to support the theory that residual stresses in steel structures are partially relieved in time at temperatures within the usual atmospheric temperature range.

In conclusion, the success of the shipbuilding venture at Seneca can be judged by the fact that the yard was awarded its first Army-Navy "E" on May 22, 1943, at which time 9 ships had been delivered, and has received an additional star for the pennant every 6 mo. until the work was completed by the delivery of the 157th and last LST.

Determination of Labor Costs in Electric Arc Welding*

By J. L. Cahill†

BECAUSE of the increased use of arc welding as a means of fabrication, considerable attention has been recently focused on the economics of its application and this necessarily involves the actual labor cost of deposition. Several methods have been employed for estimating this cost but so far as is known to the writer, none of these methods provides more than an approximate estimate. The chief difficulty in obtaining more accurate determination of costs lies in the fact that several variables enter into such calculations and it is extremely difficult to establish an inter-relationship between these variables.

The variables include (*a*) weld size, (*b*) electrode type, size and application, (*c*) basic labor cost and (*d*) the operation factor.

Obviously, the weld size is a determining factor as it represents the amount of work done. Basically there are two types of welds, namely, fillets and grooves. Mathematically the weight of metal deposited in either type of weld is a function of the cross-sectioned area and, as such, may be readily calculated.

Table 1 indicates this calculated weight per foot for fillet welds of various sizes. Figure 1 was prepared to show the deposit weight per foot of groove welds for various combinations of plate thickness, root openings and included angles. This chart, of course, is also applicable to double bevel joint designs. Similar charts can be easily prepared for other less common types of joints if desired.

The quantity of electrodes required for any job is a function of the deposited weight. For most work using E6010 electrodes the deposit efficiency is 55½% so that the actual quantity of electrodes required is 1.8 times the weight deposited.

The deposit rate is directly dependent on the size and type of electrode employed as well as the operating conditions under which these electrodes are used. Deposition data should be determined by the individual fabricator under actual service conditions. For all practical purposes, this deposition rate test is merely a time study of production work. The use of electrically

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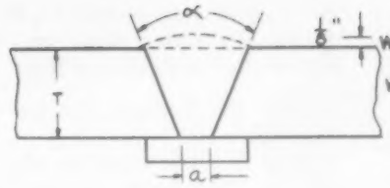
* The views expressed in this article are those of the author and are not necessarily representative of the Navy Dept.

† U. S. Navy Yard, Brooklyn, N. Y.



WEIGHT OF REINFORCEMENT = 0.213(a + 2T TAN. α/2)

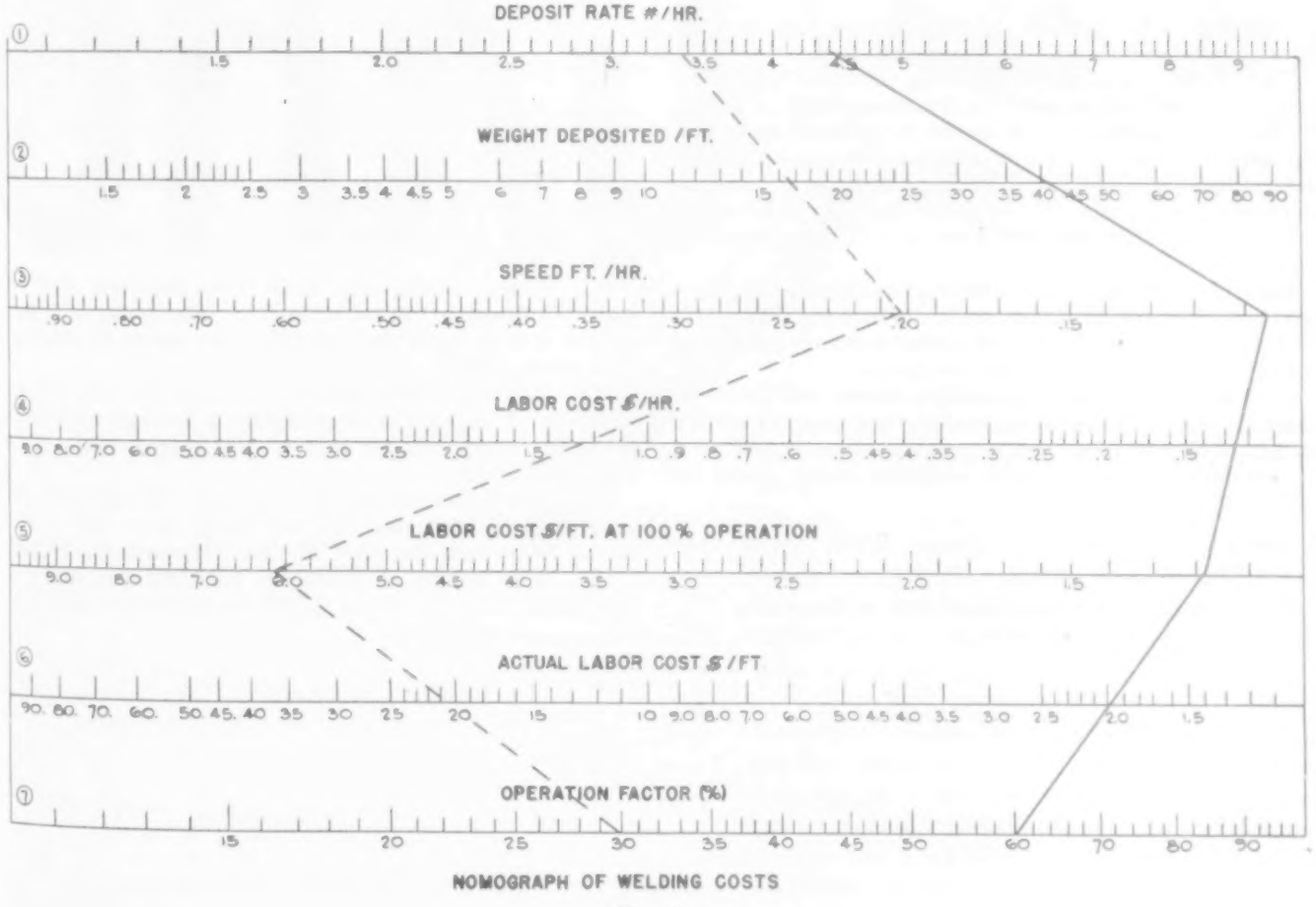
WEIGHT OF DEPOSITED WELD METAL = 3.408(aT+T² TANα/2)

TOTAL WEIGHT (#/FT.) OF DEPOSIT INCLUDING REINFORCEMENT

LBS. ELECTRODES REQUIRED PER FOOT = $\frac{\text{TOTAL WT./FT}}{0.555}$ = 1.8 X TOTAL WT/FT.

← a						→		α →									
1/2"	3/8"	5/16"	1/4"	3/16"	5/32"	1/8"	T	10°	15°	20°	25°	30°	35°	40°	45°	50°	60°	90°
.42617	.31956	.26631	.21314	.15992	.13313	.10595	3/16"	.01749	.02628	.03522	.04424	.05349	.06303	.07267	.08283	.09309	.11533	.19986
.53250	.39965	.33276	.26630	.19980	.16653	.13287	1/4"	.02796	.04205	.05624	.07096	.08541	.10074	.11642	.13240	.14877	.18453	.31950
.63917	.4794	.39956	.31946	.23967	.19959	.15945	5/16"	.04077	.06146	.08207	.10345	.12494	.14697	.16938	.19315	.21706	.26911	.46616
.7455	.55914	.46602	.37297	.27954	.23299	.18604	3/8"	.0559	.08405	.11268	.14173	.17128	.20137	.23269	.26455	.29796	.36898	.63906
.85217	.63923	.53247	.42614	.31942	.26639	.21262	7/16"	.07322	.11043	.14770	.1858	.22473	.2643	.30529	.3475	.39079	.48428	.83879
.9585	.71898	.59927	.4793	.35963	.29944	.2392	1/2"	.09325	.14012	.18788	.2360	.28544	.33575	.38763	.44132	.49657	.61512	1.0650
1.1715	.87882	.73218	.58597	.43938	.36624	.29236	5/8"	.13980	.21017	.28171	.35413	.42788	.50387	.58142	.66161	.74450	.92240	1.39932
1.3845	1.03865	.86544	.69230	.51912	.43270	.34587	3/4"	.19562	.29453	.39442	.49578	.59919	.70548	.81406	.92626	1.04272	1.29142	2.2369
1.5975	1.19814	.99835	.79897	.59921	.49915	.39904	7/8"	.26094	.39253	.52578	.66094	.79888	.94029	1.08531	1.23508	1.39026	1.72188	2.98216
1.8105	1.35798	1.1316	.90530	.67896	.56595	.45220	1"	.33540	.50483	.67601	.84995	1.0272	1.20894	1.39551	1.58809	1.78755	2.21378	3.834
2.0235	1.51782	1.26485	1.01197	.75871	.63241	.50536	1 1/8"	.41917	.63511	.84492	1.06238	1.28415	1.51109	1.74427	1.98437	2.23406	2.76707	4.79316
2.2365	1.67765	1.39776	1.11830	.83880	.69886	.55887	1 1/4"	.51247	.77137	1.0328	1.29863	1.56949	1.84712	2.13227	2.42616	2.73097	3.3826	5.858
2.6625	1.99698	1.66427	1.3313	.99863	.83212	.6652	1 1/2"	.72694	1.0938	1.46472	1.84151	2.22564	2.69124	3.02368	3.44101	3.87327	4.79667	8.307

Fig. 1



NOMOGRAPH OF WELDING COSTS

Fig. 2

operated timing equipment is imperative to minimize possibility of errors. A simple means of accomplishing this is to utilize the voltage drop in one side of the welding circuit to energize a small bell transformer which then operates as a switch in the feeder supply of a self-starting electric clock with sweep second hand. This results in clock operation only when arc is operating. Representative values of deposition test results are shown in Table 2.

The operation factor which is the ratio between the actual arc operating time and the total elapsed time may be readily determined by use of the above system. This factor obviously is influenced by the production setup, equipment, operator and several other variables. In shipyard work this factor varies between 15 and 30%. For shop work where positioners are available it may run as high as 50% or more.

Table 1—Weight per Foot—Fillet Welds

Fillet Size, In.	Weight (Lb./Ft.)
1/8	0.0266
3/16	0.0599
1/4	0.1065
5/16	0.1660
3/8	0.2396
7/16	0.326
1/2	0.426
9/16	0.539
5/8	0.666
3/4	0.959
7/8	1.303
1	1.704

The weight of electrodes required per foot—1.8 times the weight of deposit per foot. The value 1.8 is based on an over-all electrode efficiency of 55 1/2% which in turn breaks down to 14.7% stub loss and 35% spatter loss.

The basic labor cost is self-explanatory and may include overhead charges.

The various factors influencing cost of operation have been grouped together in the nomograph of Fig. 2. By using this nomograph as shown in attached examples, the actual labor cost of any welding job can be readily determined provided the following are known: (*a*) the electrode deposit rate, (*b*) the size of the weld to be made, (*c*) the basic labor cost per hour and (*d*) the operation factor.

Rate of deposition tests, which are relatively simple to run, provide the information under (*a*) and (*d*). The data of Fig. 1 and Table 1 serve as a source for (*b*) and (*c*) is readily available from production figures.

It is hoped that the nomograph shown will prove of value to engineers who have too long had to approximate estimates of weld costs because of difficulties experienced in correlation of the several variables which make up such costs.

Example of Use of Chart—Groove Welds (*Solid Line ————, Fig. 2*):

To determine the actual labor cost of depositing 1 ft. of weld in a single vee groove of 1 1/2 in. thickness with 20° included angle and 1/2 in. root opening using 1/4-in. 25-20 electrodes with an operation factor of 60%. Labor cost is $1.25 per hour:

(A) The deposit rate for the electrode is 4.40 lb./hr. (see Table 2).

(B) For the total weight deposited per foot consult Fig. 1. Run down column "T" to 1 1/2", across column "α" to 20°. Read 1.46472. Run back across column "a" to 1/2". Read 2.6625. Add 1.46472 + 2.6625 = 4.13 lb./ft. of deposit.

(C) Using nomograph draw line between 440 on scale (1) through 413 on scale (2). The point of intersection of this line with scale (3) is the speed of welding. This point is 107.

(D) Draw line between 107 on scale (3) and 125 on scale (4). The point of intersection of this line with scale (5) is the labor cost per foot at 100% operation. This point is 118.

(E) Draw line between 118 on scale (5) and 60% on scale (7). Where this line intersects scale (6) is the actual labor cost per foot of this job, namely, $1.98.

(F) The weight of electrodes required per foot for this job is 1.8 × 4.13 = 7.44 lb.

Example of Use of Chart—Fillet Welds (Broken Line - - - -, Fig. 2):

To determine the actual labor cost of depositing 1 ft. of 5/16-in. fillet weld made with 3/16-in. E6010 electrodes at a labor cost of $1.25 per hour with 30% operation factor:

Table 2—Minimum Deposition Rates—Lb./Hr. (100% Arc Time)

	Type Electrode			
Size, In.	E6010	E6020	E6011, E6013	25Cr-20Ni
1/8	2.00	2.15	2.00	2.00
5/32	2.60	2.75	2.60	2.60
3/16	3.35	3.75	3.20	3.20
7/32	4.00	4.65	3.65	3.65
1/4	5.00	5.20	4.40	4.40
5/16	..	6.80	6.20	6.20

(A) The deposit rate for the electrode in question is 3.35 lb./hr. (see Table 2).

(B) The total weight deposited per foot in 5/16-in. fillet = 0.166 lb.

(C) Using nomograph draw line between 335 on scale (1) through 166 on scale (2). The point of intersection of this line with scale (3) is the speed of welding. This point is 20.2.

(D) Draw line between 202 on scale (3) and 125 on scale (4). The point of intersection of this line with scale (5) is the labor cost per foot at 100% operation. This point is $0.0618.

(E) Draw line between 618 on scale (5) and 30% on scale (7). Where this line intersects scale (6) is the actual labor cost per foot of this job, namely, $0.206.

(F) The weight of electrodes required per foot for this job is 1.8 × 0.166 = 0.2988 or approximately 0.30 lb.

TINY GIANT WITH A HISTORY

Long before the war, the men who design your Bell Telephone System were looking for an electron tube with frequency capabilities never before attained. With it, they could transmit wide bands of telephone messages — several hundred of them — simultaneously through coaxial cable—economically, and over long distances.

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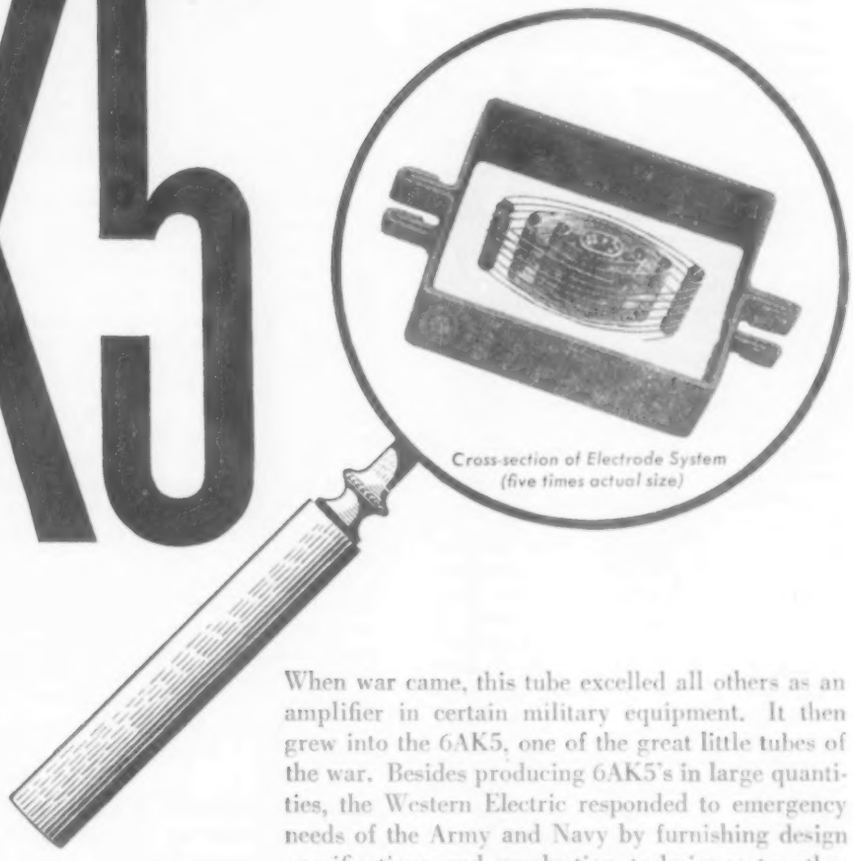
6AK5



Cross-section of Electrode System (five times actual size)

When war came, this tube excelled all others as an amplifier in certain military equipment. It then grew into the 6AK5, one of the great little tubes of the war. Besides producing 6AK5's in large quantities, the Western Electric responded to emergency needs of the Army and Navy by furnishing design specifications and production techniques to other manufacturers, of whom at least five reached quantity production. On every battlefront it helped our ships and planes to bring in radio signals.

Developing electron tubes of revolutionary design has been the steady job of Bell Laboratories scientists ever since they devised the first practical telephone amplifier over thirty years ago. Now tubes like the 6AK5 will help speed the living pictures of television, as well as hundreds of telephone conversations simultaneously over the coaxial and radio highways of the Bell Telephone System.

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THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

TWENTY-SIXTH ANNUAL MEETING AMERICAN WELDING SOCIETY

The 26th Annual Meeting of the AMERICAN WELDING SOCIETY was held in New York at the Hotel Pennsylvania on October 18th. In order to comply with restricted travel regulations, the meeting was confined to one day.

The Meeting opened at 9:30 A.M. with a brief address by President A. C. Weigel, published elsewhere in this JOURNAL, and words of welcome by Chairman E. V. David. The first hour was given over to the Presentation of Medals and Prizes, including the Samuel Wylie Miller Memorial Medal, the Lincoln Gold Medal and the RWMA Cash Prizes. Brief description of the winners of these awards is given elsewhere in this issue. Three Honorary Membership Certificates were presented to Messrs. D. S. Jacobus, J. H. Deppeler and H. C. Boardman. These were presented, respectively, by Messrs. Walter Samans, C. H. Jennings and Wendell F. Hess.

The only technical feature of the entire program was the Presentation of the Adams Lecture by Dr. Samuel L. Hoyt on the subject of Selection of Steel for Welding. This was an outstanding address enjoyed by all.

Luncheon was provided for the members of the SOCIETY and in the afternoon at 2 P.M. there was the regular Business Meeting which was opened by President Weigel. High-spot reports of the year's activities were presented by President A. C. Weigel, Secretary M. M. Kelly and Treasurer O. B. J. Fraser. H. O. Hill, Chairman of the Technical Activities Committee and Dr. C. A. Adams, Chairman of the Welding Research Council.

Below is given an Amendment to the Constitution of the A.W.S., which was offered by the Board of Directors for the consideration of the membership. In explanation of this Amendment, H. M. Priest, Chairman of the By-Laws Committee pointed out that it was the opinion of the By-Laws Committee, that this Article belongs in the By-Laws rather than in the Constitution. The Article in question reads:

"Upon the written request of ten or more members with full rights of membership stating specific reasons therein, any member classifying under Section 2, Article 1 of the By-Laws may be recommended for expulsion by the Board of Directors. If, at a regular meeting or special meeting of the Board of Directors, it is decided that there is or are presented sufficient reason or reasons for such expulsion, the Board shall notify the accused of the charges against him, by mailing a communication to the address of the accused as it appears in the records of the AMERICAN WELDING SOCIETY. He shall then have the right to present a written defense, and to appear for trial, in person or by duly authorized representative before a meeting of the Board of Directors, of which meeting he shall be notified at least thirty days in advance. Not less than two months after such a meeting, the Board of Directors shall finally consider the case, and if in the opinion of the Board of Directors the charges have been sustained, the accused may be expelled or suspended for such a period as the Board may determine, or he may be permitted to resign."

Upon motion this Amendment was unanimously adopted.

Mr. David Arnott then presented the report of the Nominating Committee for the election of New Officers. Dr. Wendell F. Hess, the incoming President, was escorted to the platform. His first business was to call upon Mr. Deppeler to present the Past-President's Emblem to retiring President A. C. Weigel. The meeting then adjourned.

A meeting of the Board of Directors was held at 3 P.M. for the approval of Committee appointments. These will be published in an early issue of THE WELDING JOURNAL.

The membership of the SOCIETY was invited to participate in the 25th Anniversary Celebration of the founding of the New York Section. A brief account of this gala occasion is given under Section Activities.

AMERICAN WELDING SOCIETY ELECTS H. C. BOARDMAN TO HONORARY MEMBERSHIP

H. C. Boardman was presented with a certificate of honorary membership at the Annual Meeting of the AMERICAN WELDING SOCIETY held in the Hotel Pennsylvania, New York City, Oct. 18th.

Mr. Boardman is research engineer for the Chicago Bridge and Iron Co., Chicago, Ill., and is a past-president of the AMERICAN WELDING SOCIETY. In addition, he is vice-chairman of the Welding Research Council of the Engineering Foundation; chairman of the University Research Committee, A.W.S.; member of the Handbook Committee, A.W.S.; member of the Boiler Code Committee, American Society of Mechanical Engineers. His technical society memberships include ones in the American Society of Civil Engineers, the Western Society of Engineers, the American Society for Metals, the American Academy for the Advancement of Science and the National Research Council, Division of Engineering and Industrial Research. He is also a member of Tau Beta Pi and Sigma Pi.

Harry C. Boardman

Mr. Boardman was born in Plainfield, Ill., April 29, 1887. He received his B.S. degree from the University of Illinois in 1910 and his C.E. from the same school in 1926. He holds an honorary E.D. from the South Dakota State School of Mines. From 1910 to 1916 he was a draftsman for the Chicago Bridge and Iron Co. Entering the Army as a private in 1916, he was discharged in 1919 as a major in the field artillery. From 1919 to 1922 he was in the automobile tire and accessory business in Kansas City, Mo.; from 1922 to 1924 was engineer and superintendent of construction for the International Filter Co., Chicago, Ill.; and, from 1924 to 1926 served as an instructor in civil engineering at the University of Illinois. In 1926 he took the position which he now holds.

He is the author of many technical articles published in various magazines and of the Handbook on Arcs, Chords and Versines.

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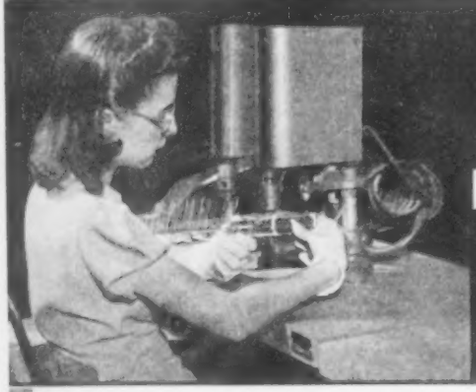

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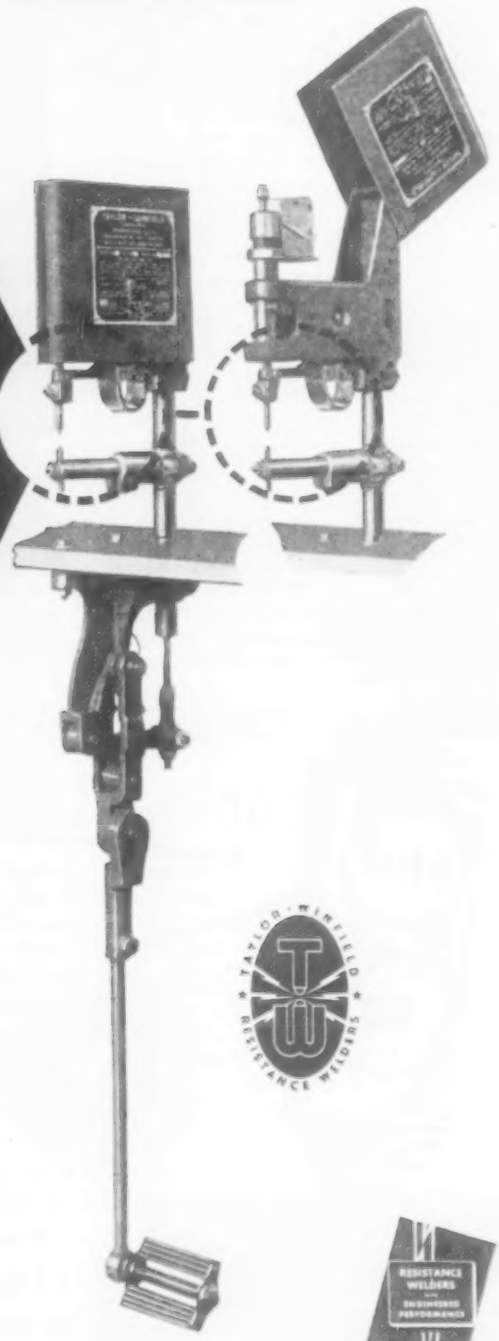

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DAVID SCHENCK JACOBUS MADE HONORARY MEMBER

Perhaps one of the best ways to describe Dr. Jacobus, who was honored on Oct. 18th by the AMERICAN WELDING SOCIETY with Honorary Membership, is to quote the opening paragraph of the presentation of the 1942 Miller Medal Award to him by Dr. H. C. Boardman.

"The medalist this year is rich in experience, deeds, wisdom and character. He is a scholar, educator and author of note, great engineer and true gentleman. His achievements have not been of the sensational type, but have resulted from steady, patient effort—sometimes in the face of much discouragement and opposition."

Dr. Jacobus was born in Ridgefield, N. J., Jan. 20, 1862. He graduated from Stevens Institute of Technology in 1884. For 22 years following his graduation, he taught at Stevens and became Professor of Experimental Mechanics and Engineering Physics. He received a degree of Doctor of Engineering in 1906. That was the year he joined the Babcock and Wilcox Co. with which organization he remained until his retirement in 1941.

He has been president of three national technical societies—The American Society of Refrigerating Engineers, the American Society of Mechanical Engineers and the AMERICAN WELDING SOCIETY.

He was awarded the Morehead Medal in 1935 by the International Acetylene Association. Dr. Jacobus was selected as National Modern Pioneer by the National Association of Manufacturers in 1940.

David S. Jacobus

Dr. Jacobus served the SOCIETY in many ways, but he will long be remembered as Chairman of the *Welding Handbook* Committee of the AMERICAN WELDING SOCIETY which prepared the 1938 and 1942 editions of its *Welding Handbook*. The Rules for marine boilers and piping bear the imprint of his mind.

Again, we quote Dr. Boardman on the occasion of the Miller Medal Award.

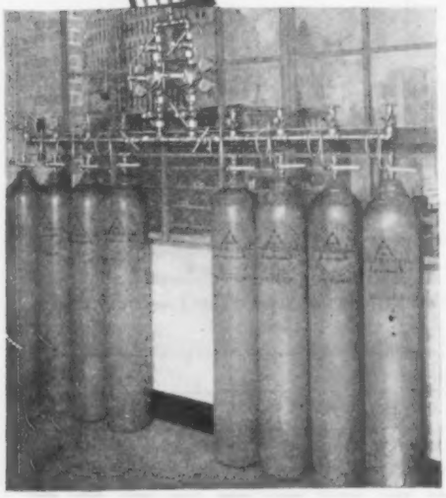
"In the engineering world at large, wherein he is recognized as a giant in the field of steam engineering, there stands out above all of his other great services his service as a member of the A.S.M.E. Boiler Code Committee which, beginning when all pressure vessels were riveted, has been continuous through the bare electrode era and into the coated electrode era until now when practically all pressure vessels are welded. He became chairman in 1936. In a very real sense the A.S.M.E. Boiler Code, which is the pressure vessel bible of the world, is a monument to him because so much of him is in it. Probably no other single document has so advanced the use of welding."

He now serves as Honorary Chairman of the Boiler Code Committee. Some additional facts concerning Dr. Jacobus are:

Made a number of tests on acetylene which began when calcium carbide was first available.

In 1896 exhibited oxyhydrogen blowpipe using oxygen and acetylene at the Franklin Institute in Philadelphia.

An interesting account of the development of Codes for Welded Pressure Vessels in which he was a leader is found in an article by Dr. Jacobus on this subject in the October 1940 issue of THE WELDING JOURNAL.



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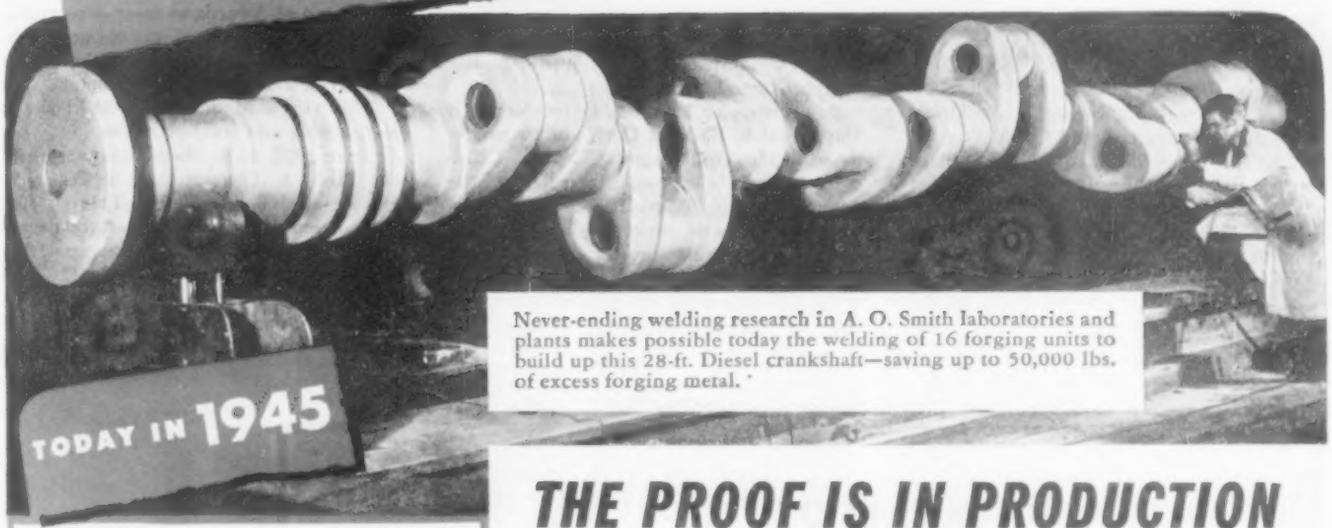

Never-ending welding research in A. O. Smith laboratories and plants makes possible today the welding of 16 forging units to build up this 28-ft. Diesel crankshaft—saving up to 50,000 lbs. of excess forging metal.

THE PROOF IS IN PRODUCTION

Prior to World War I, welding electrodes were imported from England. When war brought shipping restrictions, A. O. Smith chemists and metallurgists developed a new and radically improved type of shielded arc electrode. They coated the bare wire with paper . . . produced welds of high ductility with tensile strength equal to that of rolled steel plate.

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AMERICAN WELDING SOCIETY GIVES DOUBLE HONOR TO J. H. DEPPELER

At its Annual Meeting held Oct. 18th, in the Hotel Pennsylvania the members of the AMERICAN WELDING SOCIETY conferred honorary membership on J. H. Deppeler, who was also the recipient of the Samuel Wylie Miller Memorial Medal for the year 1944. The Miller Medal is awarded annually to the person who, in the judgment of the SOCIETY's Board of Awards, is most deserving to receive it because of conspicuous contributions made to the advancement of the welding and cutting of metals.

Mr. Deppeler is chief engineer of the Metal & Thermit Corp., New York, and was the second president of the AMERICAN WELDING SOCIETY in 1920–21. He has been a member of the Board of Directors of the SOCIETY since that time. He was made chairman of the AMERICAN WELDING SOCIETY's Filler Metal Committee in 1935 and is serving as chairman of the joint A.W.S.-American Society for Metals Committee on Filler Metal. He is also a member of the Welding Society's Technical Activities Committee, the Committee on Safety Recommendations, the Committee on Definitions and Chart, The Committee on Welding in Marine Construction, the Aircraft Welding Committee and the Subcommittee of the Committee on Standard Qualification Procedures. He is currently serving on the Battelle Program of the Weldability Committee and the Nickel

John H. Deppeler

Alloys Committee of the Welding Research Council.

Mr. Deppeler has been connected with the Metal & Thermit Corp., or its predecessor—The Goldschmidt Thermit Co.—since 1912. He was superintendent of the Jersey City, N. J., plant for many years and then became chief engineer for the company. During this time he was very prominent in developing the Thermit welding process to its present state and took out many patents on its development and on its applications. In the street railway field he developed the use of the Thermit weld for joining rails and, with the help of E. M. T. Ryder, adapted the process to be used on rails under traffic. The process has been extended to use in the steam railway field. Important applications in steel mills and in marine construction have also been directed by Mr. Deppeler.

PRESENTATION TO JOHN H. DEPPELER OF THE SAMUEL WYLIE MILLER MEMORIAL AWARD

By H. C. Boardman

Each year the AMERICAN WELDING SOCIETY donates a medal to commemorate Samuel Wylie Miller, his character, his services to welding, and especially his help to the SOCIETY in its formative years.

The recipient of this medal is chosen by the Board of Awards as most deserving of the honor because of conspicuous contributions to the advance of the science and art of welding or cutting metals.

This year's Medalist is well known in engineering and welding circles.

Since 1912 he has been connected with the Metal & Thermit Corp. or its predecessor—the Goldschmidt Thermit Co. For several years he was superintendent of the Jersey City, N. J., plant, and then became Chief Engineer, which position he still holds.

His was a prominent part in developing

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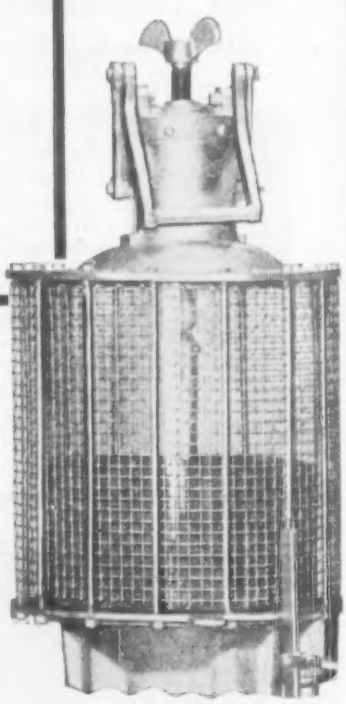

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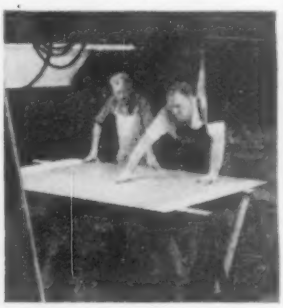

4 Rinse, first with weak ammonia solution, then with water . . . and there's your drawing on metal.

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Efficient, economical, the Kodak Transfax Process speeds production in many ways—where layouts are complex . . . where instructions must go on templates . . . where multiple reproductions are needed. For full information write: Eastman Kodak Company, Rochester 4, N. Y.

ANOTHER METHOD: Reproducing working drawings directly on template material, the Kodak Linagraph Process employs light-sensitive Kodak Linagraph Transfer Paper—laminated to the template sheet—permits "printing" the layout by either contact or projection. In the contact method, reproduction is identical in size with the original drawing. In the projection method, variation in scale is possible . . . valuable in the making of experimental models. With either method, reproduction is photographically accurate and complete; and time and money are saved.

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the Thermit-welding process. Many patents related to it are in his name. He adapted the process to the joining of street railway rails and, working with Mr. E. M. T. Ryder, to their welding while under traffic. The method has been applied to the steam railway field also, and has found many applications in steel mills and marine construction, many of them under his direction.

In 1920–21 he was the second president of the AMERICAN WELDING SOCIETY, and since then has served continuously on the Board of Directors. In 1935 he became chairman of the A.W.S. Filler Metal Committee, and is now chairman of the joint A.W.S.-A.S.T.M. Committee on Filler Metal—a post which he is eminently qualified to fill. He is also a member of many other technical committees of the SOCIETY, and is active in the work of the Welding Research Council.

He is a true gentleman and diplomat—and engineer of men as well as of materials and forces. Time after time, without ever raising his voice or losing his poise, he has demonstrated his ability to get action out of large committees, representing many conflicting views.

In the name of the AMERICAN WELDING SOCIETY and its Board of Awards, and in recognition of your contributions to the science and art of welding and cutting, I confer upon you, John H. Deppeler, the Samuel Wylie Miller Memorial Medal, and the Certificate of Award.

LINCOLN MEDAL AWARDED TO LEON C. BIBBER

Leon C. Bibber, welding engineer for the Carnegie-Illinois Steel Corp., received this year's award of the Lincoln Gold Medal and Certificate at the Annual Meeting of the AMERICAN WELDING SOCIETY held Oct. 18th in the Hotel Pennsylvania, New York. This annually awarded and valued prize is given to the author or authors of the paper published in THE WELDING JOURNAL which in the judgment of a board of awards represents the greatest original contribution to the advancement and use of welding. J. F. Lincoln, president of the Lincoln Electric Co., Cleveland, Ohio, is the donor of the prize which was given this year for the paper entitled, "Tensile Properties of Heavy Longitudinally Welded Plate Specimens Simulating Deck and Shell Joints," which appeared in the April 1945 issue of the AMERICAN WELDING SOCIETY'S WELDING JOURNAL.

Mr. Bibber was born in Portland, Me., Nov. 2, 1893. He was graduated from the University of Michigan with the degree of Bachelor of Naval Architecture in 1916 and received the degree of Master of Science in Engineering in 1917.

For a number of years Mr. Bibber worked at the plant of the Newport News Shipbuilding and Drydock Co. in Newport News, Va., in various capacities and while there, began his interest in welding. In 1929 he accepted the position of Senior Welding Engineer for the Bureau of Construction and Repair of the United States Navy Department in Washington, D. C. In 1936 he became Welding Engineer for the Carnegie-Illinois Steel Corp. in Pittsburgh, Pa. From that date to the present he has been concerned with problems of weldability of various types of steels and the applications of those steels to welded products in industry.

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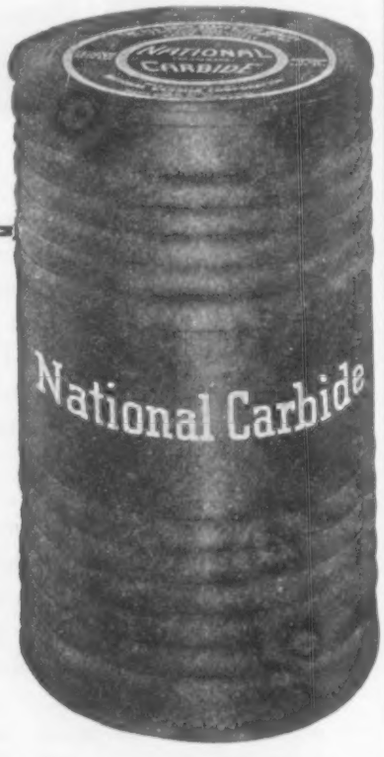

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Leon C. Bibber

Mr. Bibber is the author of numerous technical papers which have been prepared for presentation before various technical societies. He has served on many of the technical committees of the AMERICAN WELDING SOCIETY of which he is a member and, at present, he is serving as chairman of the Committee on Symbols. He also holds memberships in the Society of Naval Architects and Marine Engineers, the American Society for Testing Materials, the American Society for Metals and the American Iron and Steel Institute.

RESISTANCE WELDING PRIZE PAPERS

In order to stimulate the preparation of high-type papers for THE WELDING JOURNAL, the Resistance Welding Manufacturers Association, has offered four prizes totaling $1000, to be awarded by a Committee on Awards of the AMERICAN WELDING SOCIETY. These awards were made as follows.

$500 Prize for the best paper emanating from an Industrial Source in which the major portion of the subject matter is concerned with design for resistance welding:

L. A. McIntosh for his paper on "Resistance Welding for Economy and Quality," published in the October 1945 WELDING JOURNAL.

$200 prize for the best paper emanating from a University Source:

W. F. Hess, R. A. Wyant and B. L. Averbach for their paper on "The Surface Treatment at Room Temperature of Aluminum Alloys for Spot Welding," published in the September 1944 Supplement of THE WELDING JOURNAL.

$200 Prize for the second best paper emanating from an Industrial Source:

G. W. Scott, Jr., L. G. Sutton and J. H. Widmyer for their paper on "Radiography for Development and Control of Aluminum Alloy Spot Welding," published in the November 1944 Supplement of THE WELDING JOURNAL.

$100 Prize for the third best paper from an Industrial Source:

J. C. Barrett for his paper on "Flash Welding of Alloy Steels—Physical and Metallurgical Characteristics," published in the January 1945 Supplement of THE WELDING JOURNAL.

Honorable Mention:

H. W. Brown for his paper on "The Spot Welding of 0.0375-In. Aluminized Low-Carbon Steel," published in the September 1944 Supplement of THE WELDING JOURNAL.

E. M. Callender for his paper on "Small Portable Condenser Welding Set," published in the October 1944 WELDING JOURNAL.

F. R. Hensel, E. I. Larsen, E. F. Holt for their paper on "Problems in Spot Welding of Heavy Mild Steel Plate," published in the January 1945 Supplement of THE WELDING JOURNAL.

Biographical sketches of the Prize Winners follows.

L. A. McIntosh

Mr. McIntosh was born January 1916 at Detroit, Mich., and educated in the Detroit Public Schools, graduating from Detroit Northwestern High School in January 1934. He received his first drafting experience the following spring and summer and entered the College of Engineers, University of Michigan, with the class of 1938, continuing to work summers designing tools and dies for heavy gage steel

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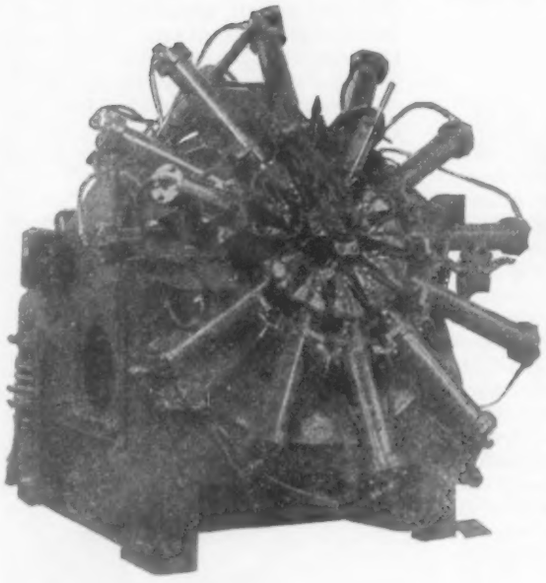

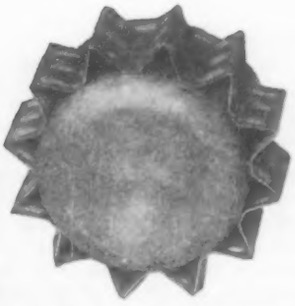

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Difficulties encountered in welding aluminum alloys were due to the narrow "margin of safety" in their thermal response. The extreme accuracy of timing heat and pressure required were difficult to attain until perfection of the "stored energy" principle combined with full electronic controls.

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Among the important advantages of current Federal Aluminum Welders are . . . increased welding speed, higher quality welds, increased volume of production per cleaning of electrodes and lower KVA demands on the power line. Remarkable uniformity and high mechanical strength make it possible to design parts where stress may be involved with a full measure of exactness not possible with old methods.

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Called Ultra Speed Spot Welders, these machines are made by The Federal Machine and Welder Company. Descriptive literature available on request. "Bulletin 515".

L. A. McIntosh

stampings. However, in 1936 he returned to Detroit and attended Wayne University night classes and later became a Registered Licensed Mechanical Engineer in the State of Michigan. His first large undertaking was in 1938 to design several automotive body "Gun" spot-welding fixtures.

In the fall of 1938 he joined the McIntosh Stamping Corp., Detroit, and subsequently was elected by the Board of Directors as vice-president in charge of engineering.

Dr. Wendell F. Hess

A biographical sketch of Dr. Hess was published in the October 1945 issue of THE WELDING JOURNAL in connection with his election to the Presidency of the AMERICAN WELDING SOCIETY.

Robert A. Wyant

Robert A. Wyant was born on a farm near Auburn, N. Y., on July 7, 1909. Having attended rural schools and the Auburn Academic High School, he became a student at Rensselaer Polytechnic Institute, and received the degree of Electrical Engineer in 1930. The following two years, he spent in the development of electric wave filters, as a member of the technical staff of the Bell Telephone Laboratories. He attended Cornell University, summer session, in 1933, taking courses in education. From 1934 through 1938 he was a member of the engineering staff at the Auburn Works of the International Harvester Co., where he first became interested in welding. His license as a Professional Engineer was granted by the State of New York in 1938.

In 1939, he went to Rensselaer Polytechnic Institute as a research fellow on the staff of the Welding Laboratory, and for the next two years was engaged in research sponsored by the Welding Research Council of the Engineering Foundation in the field of electric resistance welding. Since 1941 he has been associated with various research projects dealing with the spot welding of aluminum alloys for aircraft structures and the spot welding of magnesium alloys. The latter projects have been sponsored by various government and private agencies. He was promoted to an assistant professorship in the Department of Metallurgical Engineering in 1942, and received the degree of Master of Science in Metallurgy from Rensselaer Polytechnic Institute in 1944. He is a member of the Society of Sigma Xi, the

R. A. Wyant

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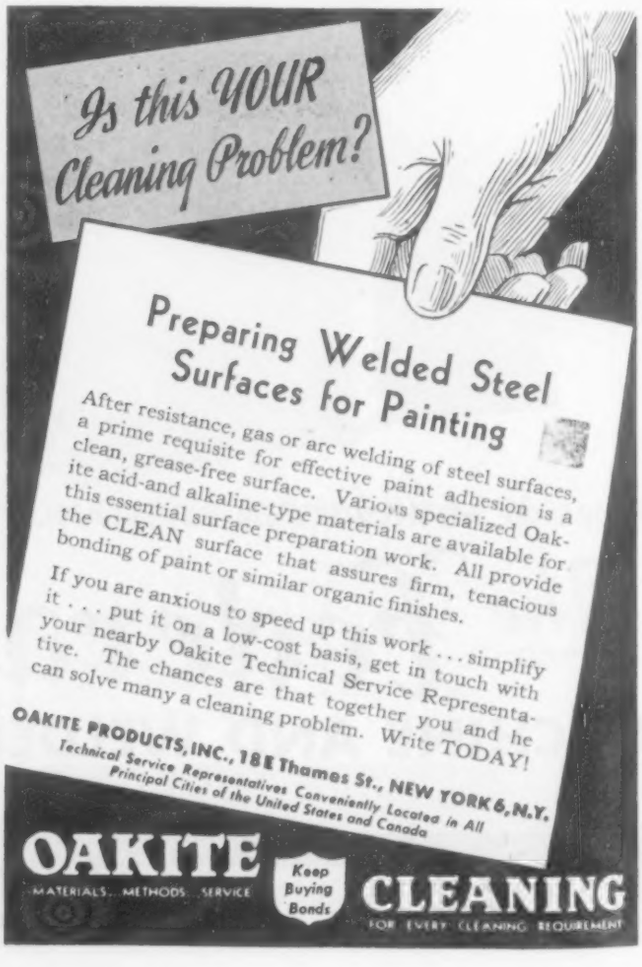
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Society for Promotion of Engineering Education, and an associate member of the AMERICAN WELDING SOCIETY. He has been an author and co-author of numerous papers pertaining to subjects in the field of electric resistance welding.

B. L. Averbach

Mr. Averbach was born in Rochester, N. Y., Aug. 12, 1919. He graduated from Rensselaer Polytechnic Institute in 1940, and received the degree of M.Met.Eng. in 1942. He served as Research Fellow at R.P.I., 1940–43 on a program for the spot welding of aluminum alloys for aircraft structures. He became Chief Metallurgist, 1943–45, for U. S. Radiator Corp., Magnesium Division. At present, he is metallurgist in Works Laboratory of General Electric Co., Schenectady, N. Y. Mr. Auerbach is author of papers on manganese alloys, spectrography and helium arc welding of magnesium. He is co-author with W. F. Hess and R. A. Wyant, of 13 papers on spot welding of aluminum.

Mr. Auerbach is a member of A.W.S., A.S.M., A.I.M.E., A.S.T.M., A.F.A., Sigma Xi, Tau Beta Pi and Phi Lambda Upsilon.

Bob Averbach

G. W. Scott, Jr.

G. W. Scott, Jr., Assistant Chief Physicist of the Armstrong Cork Co., Research Laboratory, Lancaster, Pa., was born Feb. 20, 1912, in Auburn, N. Y. He was graduated from Wesleyan University in 1934 with an A.B. Degree in Physics. He received an M.A. Degree (Nuclear Physics) from Cornell University in 1935 and a Ph.D. (Experimental Physics) from Cornell in 1938. He was a post-doctorate fellow in Applied Electronics at Massachusetts Institute of Technology from 1938 to 1940, and a Research Associate at M.I.T. from 1940 to June 1941, when he joined the Armstrong Cork Co. as a Physicist in the Research Laboratory, becoming Assistant Chief Physicist in 1942.

Since 1934 Dr. Scott has been active in research work in electronics, high voltage, resistance welding and dielectric heating. He is a member of Phi Beta Kappa, Sigma Xi, the American Physical Society, associate member of the AMERICAN WELDING SOCIETY and a member of the American Institute of Electrical Engineers.

C. W. Scott, Jr.

L. G. Sutton

L. G. Sutton, of the Armstrong Cork Co. Research Laboratory, Lancaster, Pa.,

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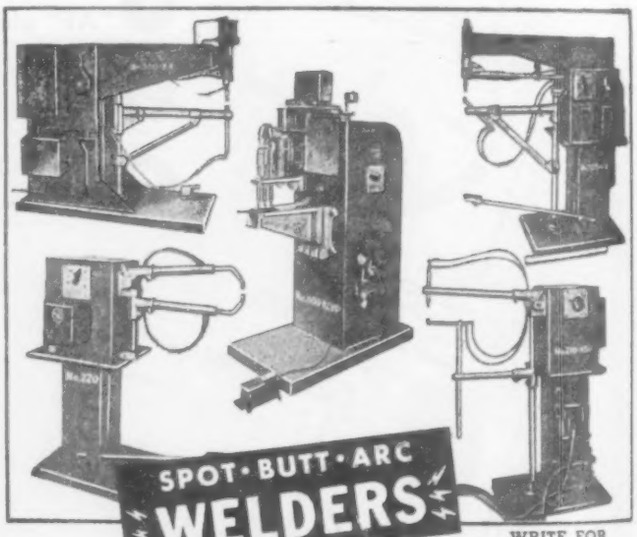

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Because of the many advantages, Phos-Copper is replacing tin and silver-base solders. For further information on Phos-Copper, ask your Westinghouse representative for book B-3201. Or write for it, to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

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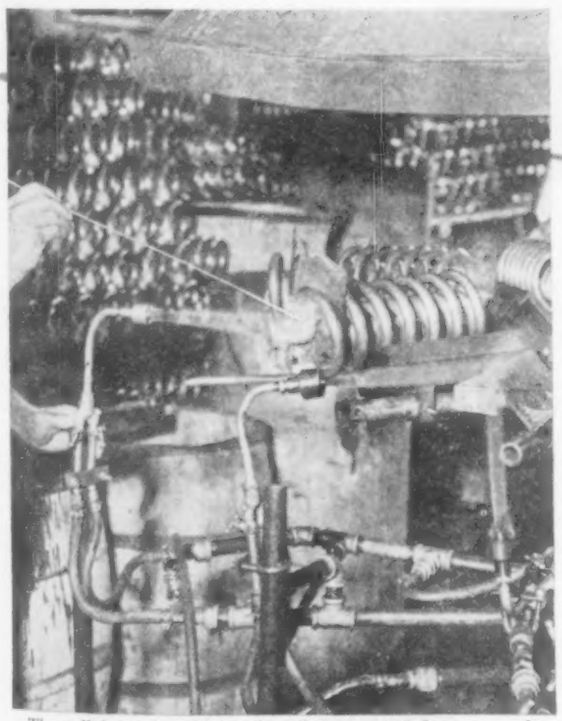

The coil being brazed has just been rotated from two other positions where gas flames preheated the joints. The flame at the brazing position maintains the heat and flows the ⅛-inch Phos-Copper rod. The ten-position rotating fixture produces 1600 brazing operations of two joints each, or 800 coil assemblies per shift.

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Phos-Copper Brazing

L. G. Sutton

was born Dec. 19, 1918, in Lemoyne, Pa. After graduation from Millersville (Pa.) State Teachers College in 1940, he became a Physicist in the Armstrong Research Laboratory.

From January 1943 until September 1945 he worked on aluminum spot-welding research and control.

J. H. Widmyer

J. H. Widmyer

J. H. Widmyer, of the Armstrong Cork Co. Research Laboratory, Lancaster, Pa., was born Feb. 28, 1897, in Lancaster. Following service in the U. S. Navy as a radio operator in World War I, he was graduated from Lehigh University in 1921 with a B.S. Degree in Chemistry. He served as Metallographer and Assistant Metallurgist of the Lancaster Steel Products Corp. from 1921 to 1926, when he joined the Armstrong Cork Co. as a Physical Chemist in the Research Laboratory. At present he is in charge of Metallography, Photomicrography and related physical research problems in Armstrong's Research Laboratory.

He is a member of Tau Betal Pi and the American Association for the Advancement of Science.

J. C. Barrett

Mr. Barrett was born on Jan. 19, 1912, Ossining, N. Y. He graduated from Massachusetts Institute of Technology, Cambridge, Mass., with the degree of B.S. in Physical Metallurgy in 1934.

J. C. Barrett

From June 1934 to February 1936 Mr. Barrett was connected with the American Manganese Steel Co. He then joined the Materials Testing Laboratory, General Electric Co., River Works, Lynn, Mass., where he remained until July 1942 when he was made Metallurgical Assistant to the Engineer of Tests, Baldwin Locomotive Works, Eddystone, Pa.

In July 1942 he took the position of Metallurgist with the Taylor-Winfield Corp., Warren, Ohio. Here he was engaged in the metallurgical analysis of electrical resistance welds.

In July 1945 he became Research Metallurgist, The Glenn L. Martin Co., Baltimore 3, Md. While his work here is more general, many of his problems concerned themselves with resistance welding. He is author of a number of papers on resistance welding.

He is a member of the American Society for Metals, he served as Chairman of the Warren, Ohio, Chapter of this Society for the 1944–45 season, and as Vice-Chairman for the 1943–44 season. He is also a member of Tau Beta Pi and Sigma Xi (Associate).

27TH NATIONAL METAL EXPOSITION

Plans have been completed for the first great postwar industrial show with the announcement this week of the 27th National Metal Exposition to be held in Cleveland's big Public Auditorium from Monday, February 4, through Friday, February 8, 1946. Originally scheduled for October of this year, the event was moved back to February to avoid any interference with heavy wartime transportation demands, according to W. H. Eisenman, managing director of the Exposition and national secretary of the American Society for Metals, sponsor of the event.

"This industrial show will be the largest ever held in America," Mr. Eisenman said. "Because of the widespread advance interest in the Metal Exposition, the floor plans which have been mailed to previous exhibitors this week showed a greater area of exhibit space than any event of this type in the history of U. S. industrial shows.

"This interest in the Exposition indicates that manufacturers are ready for reconversion and eager for the opportunity to show the new machines, materials and processes that have been developed in war and to demonstrate their possibilities for high peacetime production," Mr. Eisenman continued.

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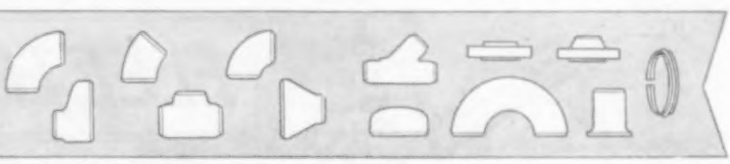


THE COMPLETE LINE OF WELDING FITTINGS AND FLANGES

"For the first time in four years," he added, "the Metal Show, as it is generally known in industry, will be a forthright effort on the part of exhibitors to sell their products."

Mr. Eisenman pointed out that the Exposition would again be held in conjunction with the National Metal Congress with the result that thousands of metal men will not only see all the new products in operation at Public Auditorium but will also have the opportunity to hear the outstanding research papers presented by scores of engineers and technical experts. Cooperating with the American Society for Metals in presenting the Metal Congress will be the Iron and Steel and Institute of Metals divisions of the American Institute of Mining and Metallurgical Engineers, and the American Industrial Radium and X-Ray Society. Many trade associations and industry groups will also meet in Cleveland during the week of this event.

BOARD OF DIRECTORS MEETING

The meeting of the Board of Directors, AMERICAN WELDING SOCIETY, was held on September 13, 1945, at the Engineering Societies Bldg., New York, N. Y.

Present were the following: President A. C. Weigel, C. A. Adams, D. Arnott, R. W. Clark, J. H. Critchett, E. V. David, J. H. Deppeler, O. B. J. Fraser, E. C. Fyke, W. F. Hess, H. O. Hill, H. W. Lawson, J. F. Lincoln, F. E. McAtee, H. W. Pierce, H. M. Priest. Staff Members: W. Spraragen, S. A. Greenberg, M. M. Kelly.

Manner of Replacement of District Vice-Presidents in the Event of Death Occurring Between Election and Time of Taking Office

This question arose in connection with the recent death of W. S. Evans, elected to the office of Mid-Southern District Vice-Presidency. The present By-Law provides only for the filling of a vacancy in the event of death, resignation or otherwise, occurring after the incumbent takes office. It was the opinion of the By-Laws Committee Chairman that the vacancy caused by Mr. Evans' death before taking office, can be filled in the manner prescribed by the present By-Law, for filling vacancies after taking office.

It was voted that vacancy in the office of Vice-President of the Mid-Southern District, caused by Mr. Evans' death, be filled in manner suggested by the By-Laws Committee Chairman, as indicated in the above paragraph, and further, that the By-Laws Committee be requested to prepare suitable revision to the By-Laws to cover deaths occurring between date of election and time the incumbent takes office, for submittal to the Board of Directors.

1945 Annual Meeting Progress Report

Mr. David reported that Prof. John R. Dunning of Columbia University had been secured as speaker at the New York Section Anniversary Dinner, the subject being "Atomic Energies—Its Potentialties in Peacetime." All arrangements for the abbreviated Annual Meeting and the New York Section Anniversary Dinner having been completed, announcements and tickets are being printed and will be mailed to the members early next week.

Welding Handbook

Upon recommendation of the Welding Handbook Committee Chairman, it was voted that Mr. Spraragen be made an advisory member of the Welding Handbook Committee.

Technical Activities Committee Report

It was voted to approve recommendation of the Technical Activities Committee for the adoption of the Tee-Bend Test as a tentative standard of the American Welding Society.

Mr. Hill reported that in May 1942, in order that the SOCIETY might make maximum contribution to the war effort, a Procedure for Preparing and Issuing A.W.S. Emergency Standards was approved by the Board of Directors. This Procedure is shown on page 25 of the 1945 *Year Book*. It will be noted that this Procedure applies to recommended practices and procedures vital to war production. In view of the peace declaration recently issued, consideration was given to the need for retaining or withdrawing this Procedure.

On recommendation of the Technical Activities Committee, it was voted to withdraw the Procedure for Preparing and Issuing A.W.S. Emergency Standards and revert to the Standard Procedure for Preparing and Issuing A.W.S. Standards.

Mr. Hill informed the Board that an election of officers was held on September 12th to fill the offices of Chairman and Vice-Chairman of the Technical Activities Committee, for term ending September 30, 1947, and that Mr. H. W. Pierce and Mr. C. H. Jennings were elected Chairman and Vice-Chairman, respectively.

He further reported that the A.W.S.-A.W.W.A. Committee on Specifications for Field Welding of Water Pipe Joints has just completed specification and has submitted it for approval as a Tentative Standard of the SOCIETY. The specification was received too late for consideration at the Technical Activities Committee meeting, and is to be submitted for letter ballot approval of that Committee and the Board of Directors shortly.

Concurrent approval is being obtained from the American Water Works Association.

It was voted that the boundaries of Sections recommended by the Section Advisory Committee be approved subject to slight changes that have been suggested by Mr. Fyke at this meeting.

It was understood that the Section Advisory Committee will endeavor to establish boundaries of Sections not yet settled and of new Sections when organized, and submit their recommendations to the Board of Directors for approval.

Resolution

On completion of the program of the last meeting of the Board of Directors, upon motion, a rising vote of thanks was extended to President Weigel in appreciation of services rendered during his term of office. Mr. Weigel thanked the Board of Directors and expressed regret travel, due to war conditions, prevented him visiting more of the Sections. He thanked those that had contributed their services during his term of office.

Adjournment

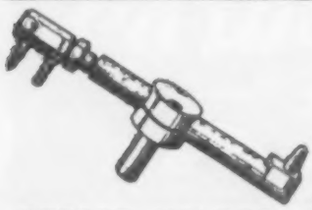
The meeting adjourned at 1:45 P.M.

POSTWAR INSTRUCTIONS OF ARC-WELDING OPERATORS

In 1939, to meet the growing demand for trained welding operators created by the increased use of welding, the AMERICAN WELDING SOCIETY organized a Committee on Minimum Requirements of Instruction for Welding Operators to prepare suitable training standards for vocational courses in welding.

In July 1942, "Part A—Arc Welding of Steel $^3/_{16}$ to $^3/_4$ In. Thick," the first in the series, "Code of Minimum Requirements for Instruction of Welding Operators," was issued, and found wide use in the training of welding operators for war production.

The Committee has studied the use of Part A and based on the experience reported, as well as experience gained by the Committee in subsequently preparing "Part B-1—Oxy-Acetylene Welding of Steel-Aircraft," a revision of Part A was undertaken to make it most applicable to



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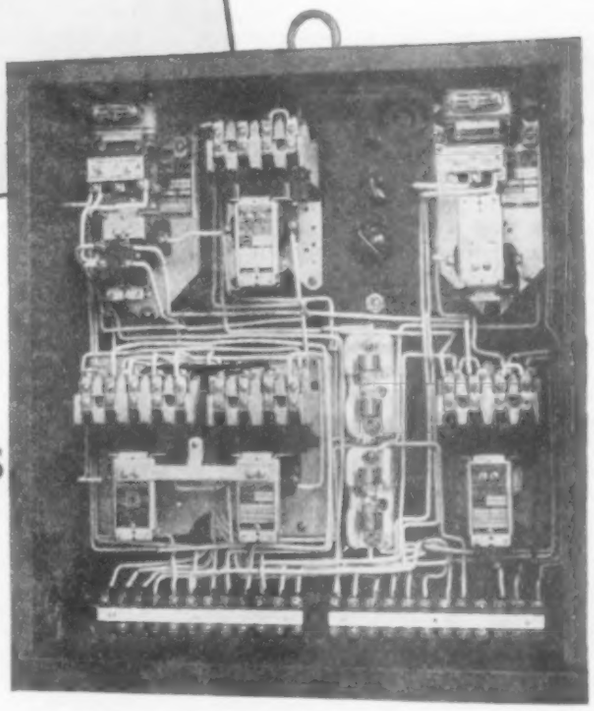

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1. Control Panel operates up to 1500 amperes D. C. by paralleling shunt wound D. C. welders or up to 3000 amperes A. C. by paralleling A. C. welders.
2. Wire feed is controlled at all times, insuring proper starting and operation for Open Arc, Protected Arc and Concealed Arc welding.
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6. Any conventional lighting supply provides power for the control circuit.

Information regarding the advantages which you may gain by the use of this new control panel is available upon request. Write and we shall be glad to have a field engineer call by appointment . . . without obligation, of course.

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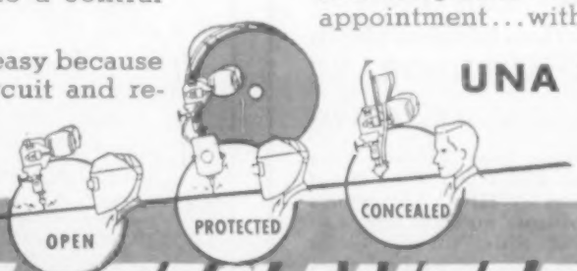

UNAMATIC WELDING

NATURALLY UNAMATIC EQUIPMENT WORKS BEST WITH UNAMATIC WIRE AND FLUXES

the postwar training of welding operators, including returning veterans.

The revision embodies primarily a modification of the manner of presentation, although some changes in the exercises and lecture information have also been made to provide for a more inclusive course.

Part A in addition to prescribing equipment and facilities of the school, exercises for each position of welding and topics for lecture and discussion, contains nine Appendices intended to be of aid to the individual student as well as the schools. Topics covered include: Design of Positioning Equipment; Design and Use of Testing Apparatus; Welding Electrodes; Suggested Exercises; and Annotated Bibliography of Publications Relating to Arc Welding.

Copies of "Part A—Arc Welding of Steel $^{3}/_{16}$ to $^{3}/_{4}$ In. Thick" may be obtained from the AMERICAN WELDING SOCIETY, 33 West 39th St., New York 18, N. Y., at a price of 50 cents per copy. Special discount is provided for group quantities.

OPENING ADDRESS 25TH ANNIVERSARY MEETING CHICAGO SECTION

By C. G. Bassler

Ladies and Gentlemen: As present chairman of the Chicago Section of the AMERICAN WELDING SOCIETY, it is my privilege to welcome you and to express our appreciation to you for joining with us in the Silver Anniversary of our founding. In doing this, you not only honor the SOCIETY, but in a larger sense you are paying tribute to the art of welding in its many forms and the part it has played in the phenomenal industrial development of our great country in the last two and a half decades. In that period, this art of joining metals has progressed until it approaches a science and it must gladden the hearts of those who are here tonight, who had a part at the start of this Chapter and, indeed, the national organization. That was in early 1920, Aug. 3rd, to give the exact date when Charter No. 2 was granted by the New York headquarters. Charter No. 1 had been given earlier that year, around March, to Philadelphia. Pittsburgh was No. 3 on August 12th, only seven days after Chicago and New York which came in October, ended the chartering of Chapters for that year. The next Chapter, Cleveland, did not come in until 1921. In Chicago, the credit for the original idea of starting the Chicago Chapter is given to Mr. L. B. Mackenzie, I understand, but he had the able assistance of Mr. Joe Jardine and Wm. H. Bleecker. These three must have done a fine job of organizing, too, because they had 57 people at that first meeting. They elected for their chairman that year, Mr. M. B. Osburn, assistant superintendent of the Pullman Car and Mfg. Co.; as vice-chairman, Mr. O. T. Nelson, president of General Boilers Co., with Mr. Mackenzie as secretary-treasurer.

In those days, the meetings were of the round-table or forum type, not particularly technical, but loud and long. Nearly all of the members were operating people, using either gas or arc equipment as maintenance tools. The dollar volume of the welding business that year, 1920, was estimated at $1^{1}/_{2}$ millions, nationally; in 1930, 10 millions; in 1940, 124 millions; and in 1944, 372 millions. This is 25,000%.

And in thinking of the many developments that were responsible for this growth perhaps in the acetylene field, the most important has been the development of the flame-treating processes, including cutting, hardening, and softening. In the arc-welding field, probably the most important was the creation of the coated electrode which made possible welding in all positions. The arc welding of nonferrous metals, automatic welding, and alternating-current arc-welding machines brought about enormous increases in the uses of arc welding. Also, there came to prominence during this period an altogether new type of welding known as resistance welding, destined to become a production tool of first magnitude, taking its place alongside the gas and the arc—the three together supplementing one another in that greatest of all tests of evaluating processes for their production capacity—World War II.

In the shipbuilding industry alone the part played by welding will ever stand as a breath-taking achievement. In World War I, the shortest time achieved by any shipyard to build a 10,500-ton ship was 243 days, while in World War II this same size ship was turned out by the hundreds in an average time of 43 days and some of the west coast yards worked on a 27-day schedule. Ships meant men and supplies and men and supplies spelled victory. Then there were tanks and metal airplanes this time instead of the wooden crates of the last war; pipe lines and yes—even the atomic bomb. But what has the Welding Society to do with this, you say. These are the achievements of industry. You are correct. They are the achievements of industry, but the prior information—the developed techniques and factual data, the "know how" if you please, was largely developed by SOCIETY-sponsored programs or cleared through the SOCIETY. And that is as it should be because this was one of the aims for which the SOCIETY was founded. Let me read you some more of these aims and purposes so that we may determine how well they have been accomplished.

1. To collect and make available authentic and up-to-date information on welding and cutting, and to be recognized as the authoritative source of such information by manufacturers in the welding field, users of the process, engineering societies and legislative bodies.

2. To provide a means for the interchange of knowledge and experience to aid in the solution of the problems of the welding art—technical, ethical and commercial—through cooperative effort.

3. To be the agent of the industry in cooperative research on important technical problems, and to serve as a common spokesman of the industry in matters pertaining to its welfare.

4. To provide opportunities for social intercourse, and thus to promote a better understanding among manufacturers, users and scientists in the welding field, and to foster a spirit of cooperation for the common good.

5. To encourage the development of welding through improvements in present applications and expansion of its use into new fields, and to develop technical and ethical standards for the welding industry.

Yes, the aims and purposes for which the SOCIETY was founded have been well met and you here who have been a part of it should be well pleased.

I should feel remiss if I did not take this opportunity to point out that the wonderful achievements of which I have been speaking were accomplished under the capitalistic-free enterprise system.

There may be some who will say that I am out of order in saying this, but I would reply that those who advocate an opposing economic philosophy never overlook any opportunity to tell what their system will

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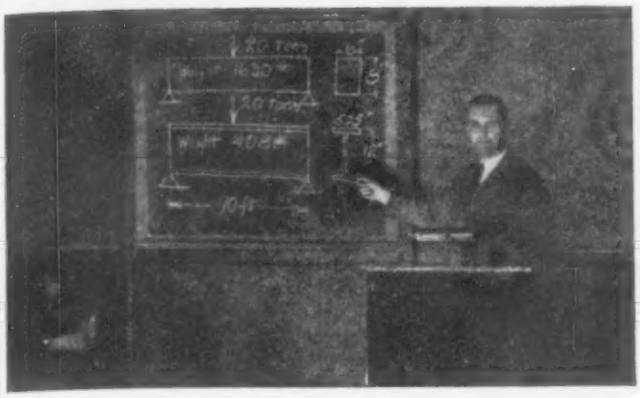

ENGINEERING. A course in welding engineering for shop supervisors, engineers, designers and executives. Held regularly in Cleveland at Lincoln plant. A valuable "eye opener" for ways to improve products and cut costs. 5 days' instruction by nationally prominent authorities. Write for details and schedule of dates.

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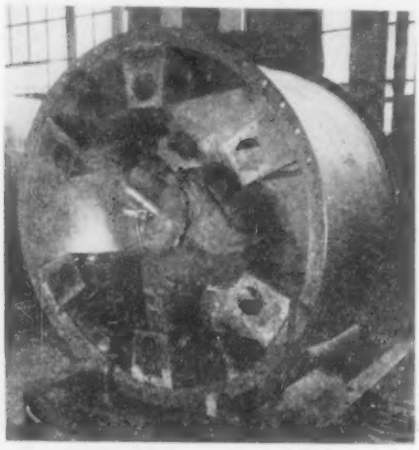
ARC WELDING

do and I think it is high time that the recipients of the benefits of free enterprise speak out and say—not what their systems will do but what their system has done.

I thank you.

WELDING NEW CONTAINERS

A welder at the Warren City Manufacturing Co., the Warren, Ohio, subsidiary of Graham-Paige Motors, works on an interior bracket in a new-type aircraft engine container. The motor rests on shock-



absorbing rubber cushions attached to the six brackets shown. Completed units, 8 ft. tall and 5 ft. in diameter, protect motors from moisture and rough handling during shipment.

SILBRAZ* JOINTS

The Silbraz Joint—the modern threadless connection that actually bonds I.P.S. copper tubing and brass pipe into a single "one-piece" pipe line—is thoroughly described in Airco's new 16-page, 2-color booklet, "How to Cash in on the Silver Ring."

Profusely illustrated, the booklet shows how Silbraz Joints are made from patented bronze pipe fittings, valves and flanges—containing a factory inserted ring of silver brazing alloy in each port opening. The literature shows that when brass pipe or I.P.S. copper tubing is properly inserted in these fittings and the assembly is brazed, the resulting joint is stronger than the pipe itself . . . a joint that is leakproof; that will not creep or pull apart under any pressure which the pipe itself can withstand.

Additional photographs and text show how the Silbraz Joints resist corrosion and vibration; how they simplify and speed up installation, making it a simple matter to run lines even in hard-to-get-at places.

Other explanatory sections describe the Aircobraze Outfit for making these joints and the many other uses for the outfit.

Copies of the booklet, NO. ADG-2017, are available on request from Air Reduction Sales Co., 60 East 42nd St., New York 17, N. Y., or any local Airco office.

* Registered—U. S. Pat. Off.

AIRCO WELDING ACCESSORIES

An up-to-date price list and catalog of Airco gas welding and cutting supplies and accessories has recently been published by Air Reduction, 60 East 42nd St., New York 17, N. Y. This 16-page booklet contains illustrations, descriptions, engineering data and current prices.

Types of equipment covered include: welding rods, brazing and welding flux, hose, brazing alloys, goggles and spectacles gloves for gas welding and cutting, and sparklighters and tips. Also listed are: carbon rods and plates, hardfacing rods, cobalt borium inserts, pea borium, and other items.

Information concerning properties and uses accompanies each article listed. Wherever possible, precise quantitative data are supplied. Numerous photographs and sketches supplement the text.

Ordering is facilitated by the listing of sizes and stock numbers in easily read columns. Complete directions for ordering are included.

The booklet also lists the addresses of Airco offices throughout the country from which these gas welding and cutting supplies can be supplied promptly.

Copies of this price list may be obtained by writing for Catalog No. 40 to Air Reduction, 60 East 42nd St., New York 17, N. Y., or to the nearest Airco office.

SPECIAL LENGTH BOILER TUBING TAILOR-MADE BY OXYACETYLENE PRESSURE WELDING

Boiler tubing, tailor-made to any desired length, is fabricated from standard-length tube stock by the use of oxyacetylene pressure welding. Besides welding short lengths of tubing to standard 20-ft. lengths, this boiler manufacturer also uses the process to join together standard lengths. In this manner continuous tubing 95 ft. in length has been produced. Production delays can now be avoided since tube stock of suitable length is readily available.

In welding with this process, squarely cut surfaces are butted together under pressure. While this pressure is maintained, the joint is heated by means of a ring of oxyacetylene flames to a high temperature but below the melting point of the steel. Increased pressure is then

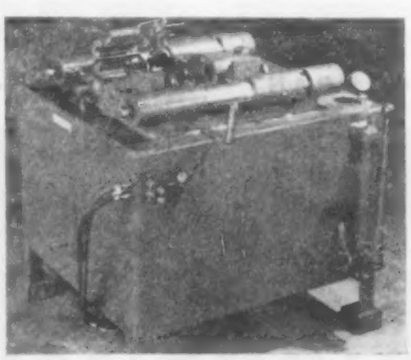


Fig. 1—Special-Length Tubing of Standard and Extra Heavy Weight Is Welded from Standard Lengths with This Oxyacetylene Pressure-Welding Machine

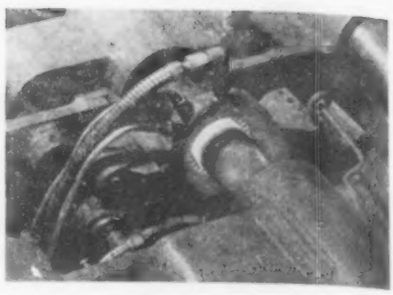


Fig. 2—Closeup Showing 2-In. Tubing Being Pressure Welded. The Slight Thickening in the Vicinity of the Joint Shows That Plastic Upset Has Just Begun

applied to the work by means of a hydraulic pump and continued until upsetting of the joint occurs, producing a weld of high quality.

The oxyacetylene pressure-welding machine is shown in Fig. 1. Work is clamped in the machine by means of two split jaws. In the picture the stationary left-hand jaw is open to demonstrate the method of introducing and removing the work. A special ring-type heating head, also open, is shown between the jaws. The control valve for gases is on the left front of the machine. The hydraulic pressure applied to the clamping and push-up pistons is provided by the pump shown at the right of the machine.

The ends of the tubing to be pressure welded are prepared for welding by a simple cut-off operation done on a lathe. In this manner, clean, squarely mated edges are produced. Such careful edge preparation is necessary for making consistently strong welds in tubes subject to high temperatures and pressures. With the two lengths of tubing clamped into the machine, the initial pressure is applied and the welding flames are lighted. During the heating operation the welding operator positions the welding head directly over the joint. A slight lateral movement of the head is used during the last few seconds to prevent any local overheating or excessive surface fusion. The pressure on the joint is controlled by a helper.

Both heating and pressure are maintained until plastic upsetting occurs. The weld is completed when a predetermined amount of shortening has occurred in the workpiece. The joint is then welded and the flames turned off. The beginning of such a plastic upset is shown in Fig. 2. The work being welded here is carbon steel tubing with a 2-in. outside diameter. An initial pressure of 900 psi., which is gradually increased to 2200 psi., is used in upsetting this material. The tubes are stress relieved by simply reheating the cooled welded areas to a dull red heat and allowing them to cool slowly in air. After being welded and stress relieved the pipes are bent to the proper shape and are then ready for installation.

WALLNER PROMOTED

L. B. Wallner has been appointed district welding engineer at Duluth, Minn., by Lincoln Electric Co., replacing I. R. Bartter who was promoted to welding engineer at Lincoln's Grand Rapids, Mich., office.

Leak Proof Gasoline Cans Seam Welded in Seconds

(Photograph Courtesy Noblitt Sparks Industries)

"Sewing" the sides of this gasoline tank takes only a few seconds, using Mallory Seam Welding Wheels. In less time than it takes to describe the operation, a sturdy, liquid-tight welded container for gasoline is fabricated.

Two factors help assure accurate high-speed production. One is the cooling of both wheel and weld by running water throughout the welding operation. The other plus factor is that seam welding wheels are made of Mallory 3* an alloy with high electrical conductivity and excellent wear resistance. *Results:* strong, clean welds; minimum down time for dressing the welding surfaces; and long electrode life.

Industries, fabricating both ferrous and non-ferrous metals, depend upon Mallory for *superior electrode materials*, including Elkaloy* A, Mallory 3* Metal and Elkonite*. Today they are using many thousands of Mallory standard spot welding tips and holders, in addition to seam welding wheels, flash, butt and projection welding dies for specific applications. Mallory pioneering is helping to win new friends for resistance welding as a technique for high speed production.

Write today for help on your specific resistance welding problems. Ask for your free copy of the latest catalog on Mallory electrodes.

A "Must" for Welding Engineers

You need the improved, revised, expanded Mallory Resistance Welding Data Book (3rd Edition), containing useful information on resistance welding methods, machines and materials. Free to those using resistance welding, when requested on company letterhead. Price to students, libraries and educational institutions: $2.50 per copy, postpaid. Board covers, 8½" x 11", 160 pages.

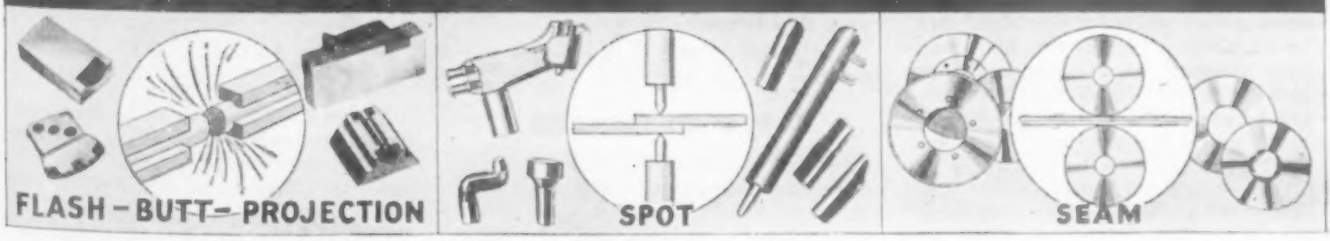
*Reg. U. S. Pat. Off.

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

In the United Kingdom, Made and Sold by Mallory Metallurgical Products, Ltd., London.

P. R. MALLORY & CO. Inc

MALLORY *Standard Resistance Welding Electrodes*



Wallner received his B.S. degree at Stout Institute, Menomonie, Wis., and studied internal combustion engines at General Motors Technical School. From 1936 to 1938 he was welding instructor at Vocational and Adult Educational School, Janesville, Wis., and later taught gas and electric welding at the Industrial Education Department for the Board of Education, Duluth, Minn.

For the past five years Wallner held the post of superintendent for Zenith Dredge Shipbuilding Company, Duluth, Minn. He is a Member of the AMERICAN WELDING SOCIETY.

EYE PROTECTION

Experiments with baby chicks reveal that exposure of eyes to invisible ultraviolet light ranging from 300 to 365 millimicrons in wave length—a range previously considered harmless by some authorities—delays dark adaptation and impairs visual functions even when the eyes themselves show no obvious injury.

Dr. Ernst Wolf, of the Harvard Biological Laboratories, reports the discovery in the August issue of the *Proceedings of the National Academy of Sciences*. The eye research was sponsored by American Optical Co., Southbridge, Mass.

As human eyes could not be utilized in view of the potential danger, Dr. Wolf selected baby chicks for testing because the visual characteristics of their eyes approximate closely those of a human, and also because chicks obligingly keep their eyes wide open during exposure to ultraviolet.

After a year's study of the effects, he discovered that the ultraviolet light in question definitely impaired the functioning of the chicks' visual mechanism even though under some conditions no obvious pathological changes in the eyes could be observed.

He therefore concludes that protective lenses excluding the dangerous rays should be worn by welders and their helpers, skiers, fliers, sun bathers and others exposed to the radiations.

In explaining his investigations Dr. Wolf points out that light rays can be accurately measured. Visible light rays range in length from about 400 to 750 millimicrons (a millimicron is $^1/_{25,400,000}$ of an inch). The invisible ultraviolet region starts below 400 millimicrons and includes all shorter waves until air absorbs them around 190 millimicrons.

THERMIT WELDING OF SHIP FRAMES

Fabrication of stern frames of cargo ships by Thermit welding is graphically portrayed in a 16-mm. sound and color motion picture made for the Metal and Thermit Corp. The 20-min. film completely visualizes the Thermit process by which thousands of stern frames have been welded during the war without failure of a single weld being reported. Prints are available without charge for showing to Local Sections of the AMERICAN WELDING SOCIETY, the A.S.M.E. and other organizations, as well as interested companies, by request to the Metal and Thermit Corp., 120 Broadway, New York, N. Y.

X-RAY INSPECTION AND THE ATOMIC BOMB

The practical realization of the universe-shaking atomic bomb represents a typically democratic process. Its conception in the minds of our greatest scientists was followed by the finest demonstration of team work in the history of the world. In a race against time, many experts in many fields gave their fullest assistance and cooperation.

At the Hanford, Wash., division of the project, an X-ray inspection program was required whose magnitude was one of the largest ever performed. Because of their reputation and facilities in this field, Triplett & Barton Inc., Burbank, Calif., was selected for that part of the work.

This was a field job, located in a desert waste where ice in winter and heavy wind and dust storms in summer had a devastating effect on delicate equipment. It was miles from supplies and had only construction camp accommodations and untrained labor on which to draw. And yet, laboratory quality had to be obtained—quality which normally would have only been possible under the most ideal conditions.

Triplett & Barton found it necessary to design and manufacture special jigs, X-ray coolers, expansion tanks, power transformers, magnetic and contoured film holders and many other special devices. In addition, they created a new type of film which was manufactured for their sole use by the du Pont Corporation.

In all, working 24 hr. a day, thousands of lineal feet of welds were X-rayed. More than 15 years of successful X-ray experience, a highly skilled technical and engineering staff and many special manufacturing facilities all went into this project. Its successful conclusion has given the world a new conception in the field of power.

SUSTAINING MEMBER

The A. O. Sutton Corp., Aircraft Welders Division, Wichita, Kan., has been through the war years engaged in the fabrication of airplane motor mounts, nacelle frames, tail wheel assemblies, landing gear supports and carburetor apparatus. They contributed to the performance of the B-29 Super Fortress, A-25 Hell Diver, C-46 Commando and many others.

The Vornadofan Division is at present manufacturing a new and revolutionary line of air circulators known as The "Vornadofan." Distributor orders received indicate capacity production for some time to come.

L. W. CLARK PROMOTED

Lemore W. Clark came to The Detroit Edison Company in 1928 and has just been appointed Assistant Superintendent of the Underground Lines Department according to announcement by James W. Parker, President.

Mr. Clark is a graduate of the University of Wisconsin with a degree of Electrical Engineering and before his recent appointment worked in the Company's System Engineering Division.

L. W. Clark

BY-LAW AMENDMENTS

At the Executive Committee meeting held on March 15, 1945, and the Board of Directors meeting held on June 28, 1945, the following By-Laws amendments and new rulings were approved. In accordance with the established policy of the SOCIETY, these amendments and rulings are published in THE WELDING JOURNAL 30 days in advance of their submittal to the voting membership.

Approved March 15, 1945

ARTICLE V

SECTION ORGANIZATION

Section 9. Section Exhibitions.—Sections shall obtain approval of the National Board of Directors *or Executive Committee* before promoting an exhibition.

ARTICLE X

MANAGEMENT

Section 7 (c). The Secretary shall be, ex-officio, a member of the Executive Committee.

Section 8 (e). The Treasurer shall be, ex-officio, a member of the Committee on Permanent Funds.

Reletter present paragraph (e) as (f).

Section 10. The Assistant Treasurer shall be, ex-officio, a member of the Finance Committee, *and of the Committee on Permanent Funds.*

ARTICLE XII

COMMITTEES

Section 1. Executive Committee. An Executive Committee consisting of not less than five members of the Board of Directors, the Chairman of the Welding Research Council and the Chairman of the Technical Activities Committee, shall ex-

525 Lap weld seams per HOUR!

"AIRGRIP" Non-Rotating Cylinders on Resistance Welding Machine of the Resistance Welder Corp., Bay City, Mich. Either end of the "AIRGRIP" Non-Rotating cylinder can be removed, leaving rest completely assembled.

By equipping this resistance welding machine with EIGHT*

AIRGRIP

Dual Action

NON-ROTATING CYLINDERS

Production capacity is stepped up, makes lap weld seams on 525 cylindrical containers in one hour!—and quality, uniformity and smoothness of welds are improved. "AIRGRIP" Cylinders do four jobs: (1) They clamp the work. (2) They unclamp it. (3) They lock fixtures. (4) They apply welding pressure.

"AIRGRIP" Cylinders have *no tie-rods.* Ample strength is provided by making the metal of cylinder walls extra thick —$\frac{1}{8}$ of an inch.

"AIRGRIP" Non-Rotating Cylinders speed production in many ways. Tell us about your machine operations. Our engineers will investigate your requirements, make recommendations.

* On this welding machine the "AIRGRIP" Cylinders operate in pairs because two cylindrical containers are welded simultaneously.

OTHER ANKER-HOLTH COST REDUCERS include "AIRGRIP" Chucks and Rotating Cylinders, Air Operated Collets, Arbors, Mandrels, Drill Press Chucks, 2- and 3-Jaw Finger and Compensating Chucks, Lubricating Assemblies, 3- or 4-way Air Valves (hand or foot operated), etc. Also Hydraulic Power Units and Fittings.

Representatives in all principal cities. Write for Bulletins.

ANKER-HOLTH MFG. COMPANY

2798 Connors Street Port Huron, Michigan

1295

When buying new lathes, specify "AIRGRIP" Chucks and Cylinders

ercise, at times when the Board of Directors is not in session, such part of the authority of the Board in the administration of the affairs of the SOCIETY as may from time to time be delegated to it. The National Secretary, the Director of the Welding Research Council and the Technical Secretary of the SOCIETY shall be ex-officio, members of the Committee without the right to vote.

Section 10. Technical Activities Committee.

In the 13th line delete "without the right to vote."

Section 14. Committee on Permanent Funds. Revise first paragraph as follows:

A Committee on Permanent Funds consisting of five members, each to serve for five years, one member of which shall retire each year and the member senior in respect to service shall be Chairman. The Treasurer *and Assistant Treasurer* of the SOCIETY shall be, ex-officio, members of this Committee.

Approved June 28, 1945

ARTICLE XII

COMMITTEES

Section 14. Honorary Membership and Honorary Directorship Committee. A Committee on Honorary Membership and Honorary Directorship of five members comprising the President, First Vice-President, Second Vice-President, and the two latest Past-Presidents, who are living, and continue to be members, whose duties shall be to present a statement of qualifications and make recommendations to the Board of Directors regarding all nominees presented for Honorary Membership and Honorary Directorship in the SOCIETY and to arrange for the presentation of the certificate.

Reletter Sections 14 through 22 as 15 through 23.

ARTICLE II

ELECTION OF MEMBERS

Section 1. Honorary Members. Nominees for Honorary Membership may be submitted to the Board of Directors in writing by any corporate member of the SOCIETY. Such nominations shall state the qualifications of the nominees for such membership *and shall be referred to the Honorary Membership and Honorary Directorship Committee for its recommendations.* Honorary Members shall be elected by unanimous vote of the Board of Directors, except that no member of the Board of Directors shall vote upon his own admission.

ARTICLE IX

NOMINATION AND ELECTION OF OFFICERS

Section 8. Honorary Directors. Nominees for Honorary Directorship may be submitted to the Board of Directors in writing by any corporate member of the SOCIETY. Such nominations shall state the qualifications of the nominee for this office *and shall be referred to the Honorary Membership and Honorary Directorship Committee for its recommendations.* Honorary Directors shall be elected by unanimous vote of the Board of Directors, except that no member of the Board of Directors shall vote upon his own admission. They shall hold office for life or until removed from office by majority vote of the Board of Directors.

ARTICLE XII

COMMITTEES

Section 13. Committee on Awards. A Committee on Awards consisting of five members each serving a period of five years, one member retiring each year. The member senior in respect to service shall be Chairman. It shall be the duty of this Committee to make the awards and nominate those to present honorary lectures at the Annual Meeting and to arrange for the presentation of such medals, certificates or other awards as may be authorized by the Board of Directors.

Upon authorization by the Board of Directors, the President may appoint subcommittees to this Committee for stated terms to provide for the prosecution of some particular project or projects.

RULING OF BOARD OF DIRECTORS

June 28, 1945

Attendance at Board Meetings. Members of the Executive Committee, who are not members of the Board of Directors, shall be invited to attend meetings of the Board.

Employment Service Bulletin

POSITIONS VACANT

V-177. Silver Brazing Alloys. Prominent manufacturer of silver brazing alloys and fluxes has opening for salesman demonstrator with shop background. Location New York area.

V-178. Business Opportunity. For sale: Old-established and well-developed welding equipment and supplies business, located in a thriving industrial center in in New York State. Exclusive distributors for all the "big name brands" in the welding manufacturing field. Must sell because of ill health.

V-179. Engineer of Tests, to take charge of commercial and industrial structures and material tests. M.S. degree and laboratory experience desirable. Opportunity to work for doctorate. Salary $3000.00 or more for 12 months depending on experience. One month vacation with pay.

V-180. Research Engineer, to work on industrial research program. Advanced degree and some experience in testing and vibration theory desirable. Salary $3600.00 or more depending on experience.

V-181. Research Fellows, to work half-time on industrial research programs and study half-time for M.S. or Ph.D. degree. One of these is an American Welding Society Fellowship Program which will start Feb. 1, 1946. Salary $1080.00 for 12 months together with freedom from tuition fees. Extra compensation during summer months may be obtained by working full time.

Applications for the last three positions above should contain complete scholastic and experience record and should be sent to Dr. Bruce G. Johnston, Associate Director, Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa.

SERVICES AVAILABLE

A-505. Army officer returning from overseas desires to purchase a suitable welding business. Also would be interested in part ownership combined with services and investment. Northeastern location preferred.

A-506. 10 years experience in the welding field as follows: $2\frac{1}{2}$ years in college (majoring in welding engineering), 3 years as a welder, 4 years as a welding instructor and welding specialist, and a year as a welding engineer. Have taught both electric and oxyacetylene welding of steel, cast iron, aluminum and aluminum alloys, brass, copper, and stainless steels. Also single and twin carbon arc and automatic carbon arc. Also familiar with welding metallurgy, production methods, production control and the development of welding procedures.

A-507. Have layed out steel directly and indirectly, have fitted in shops on boilers, tanks, machinery and pipe, shipfitted on new construction and repair work; welded with the electric arc on new construction and repaired the same; welded with the Acetylene-Oxygen torch on pipe, tanks, radiators, etc.; have used heavy-duty cutting torch on heavy steel casting work in steel foundries and light structural and plate work. Can lay out welding sequences and procedure for small or large all-welded fabrication; can set up assembly line welding fabrication methods. Served as Foreman and Inspector. Age 40, best of health and willing to accept employment anywhere.

A-508. Metallurgist, graduate, 5 years' experience in research and development in resistance welding, soldering, and brazing aluminum alloys, and steel. Handle production trouble-shooting in related fields.

RESISTANCE WELDERS PAMPHLET

An attractive, illustrated technical pamphlet has been prepared on the subject of resistance welders by The Taylor-Winfield Corp., Warren, Ohio. The pamphlet describes the principle of resistance welding, the development of the different types of resistance welding machines, the particular features of The Taylor-Winfield products and detailed description of bench welders, portable welders, press welders, Hi-Wave welders, seam welders, flash butt welders and spot welders for specific purposes. Copy available on request.

BRONZE WELDING BULLETIN

A new bulletin describing Phos-Trode, a shielded arc, phosphor bronze welding electrode, has just been issued by Ampco Metal, Inc., Milwaukee 4, Wis. Bulletin W-7 is well illustrated with views of typical welds and tests, contains weld deposit physical properties, recommended amperage, welding procedure and a list of typical applications.

Phos-Trode is a companion line to Ampco-Trode coated aluminum bronze electrodes.

Copies of Bulletin W-7 will be sent on request.

Roll it to the Job!

Portable MAGNAFLUX* Unit Provides New Convenience in Weld Inspection

Highly mobile, self-contained—this new Magnaflux unit simplifies welding inspection . . . Move it around as needed . . . Save needless handling of heavy parts. Through magnetic particle inspection, Magnaflux provides quality control for the welding shop . . . Its indications are positive, easily interpreted, *inescapable.*

With Magnaflux, every weld can be examined non-destructively—quickly, economically. Magnaflux detects thermal cracks, lack of penetration and fusion, slag inclusions and other defects that cause rejections. The shape, size and location of hidden flaws are "high-lighted" in minute metallic particles.

This new KH-2 Magnaflux unit, illustrated with the XB-2A Powder Blower, gives low-voltage, high-amperage outputs—both AC and half-wave rectified current, for either AC or DC magnetization or demagnetization after inspection.

Only Magnaflux equipment and materials provide the thorough inspection that builds confidence in your weldments. Why risk failures? Write today for complete information and free copy of "Routine Inspection and Salvage of Machinery Weldments" by James O. Owens.

*Magnaflux, Registered U. S. Patent Office, a trade mark of the Magnaflux Corporation applied to its equipment and materials for magnetic particle inspection.

MAGNAFLUX CORPORATION

5922 Northwest Highway, Chicago 31, Illinois

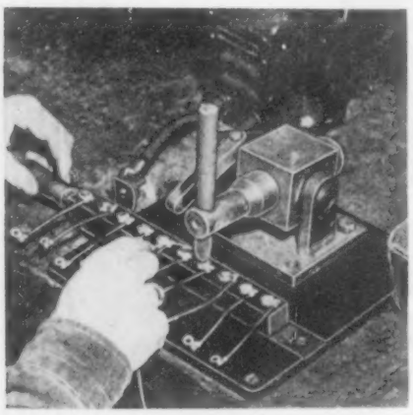
New York • Detroit • Dallas • Los Angeles • Cleveland • Birmingham

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

SOLDERING LEADS TO TERMINALS

The use of a holding fixture and soldering transformer for soldering dynamotor leads to a terminal has greatly speeded up production at the Small Motor Division of the Westinghouse Electric Corp., Lima, Ohio.



This Soldering Transformer and Holding Fixture Has Greatly Increased Production

After the fixture holding the terminals is positioned with the left hand, the carbon electrode, which is connected to one of the transformer leads, is lowered until it touches the terminal. This completes the circuit since the fixture is connected to the other transformer lead. Immediately there is enough heat created to melt the solder which flows over the face of the clips.

ENGINE-DRIVEN WELDER

This lightweight but husky, full-capacity 200-amp. "Simplified" engine-driven arc welder is the first postwar model to be announced by The Hobart Brothers Co., Troy, Ohio. Completely enclosed in a compact steel canopy with hinged side panels and powered with a sturdy 26-hp., four-cylinder engine for economical operation, this new unit has a wide range of 40 to 275 amp.

Multi-range Dual Control of welding current makes it easy for the operator to adjust voltage and amperage relationship to the fine degrees that are required of present and future welding applications or for use with all present and forthcoming electrodes. The Multi-range Dual Control wheel on the front of the generator control panel corresponds to the "station selector" of a modern radio receiver and the volt-ampere adjuster located inside the wheel corresponds to the radio "volume control." With 10 ranges of welding current and 100 steps of volt-ampere adjustment in each range, the Hobart Multi-range Dual Control makes available 1000 combinations of open circuit voltage and welding current for selecting any desired arc characteristics.

Remote Control, a standard equipment feature of all Hobart welders, allows the volt-ampere adjuster to be easily removed from the control panel for use with an ordinary extension cord so that the operator can adjust the welding heat right at the work, eliminating repeated trips between the welding work and machine.

Standard equipment also includes the mercury-type idling device which automatically idles the engine when not in use, cutting down on fuel consumption and engine wear.

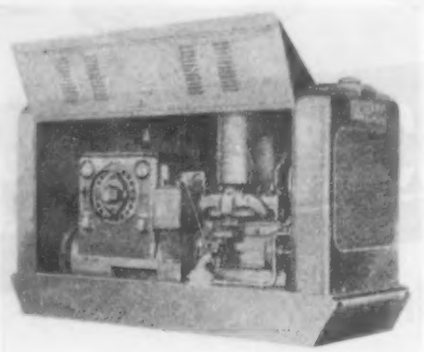


Illustration shows the stationary model with newly designed steel skid mounting, beveled at both ends with tubular end cross members for easy skidding. Portable mountings on a 2-wheel pneumatic tired trailer or on 16-in. shop type wheels are also available.

1945 OAKITE VICTORY CONFERENCE

Highlighting each of the 1945 Victory Conferences of the Oakite organization, held in New York and Chicago during October, was a vast exchange of technical information on cleaning, descaling, derusting, degreasing and related operations, particularly as applied to peacetime manufacture of civilian products. In addition to the entire field forces of more than 140 Oakite Technical Service Representatives, these conferences were attended by the staffs of the Mechanical Engineering, Chemical and Research Laboratories of Oakite Products, Inc.

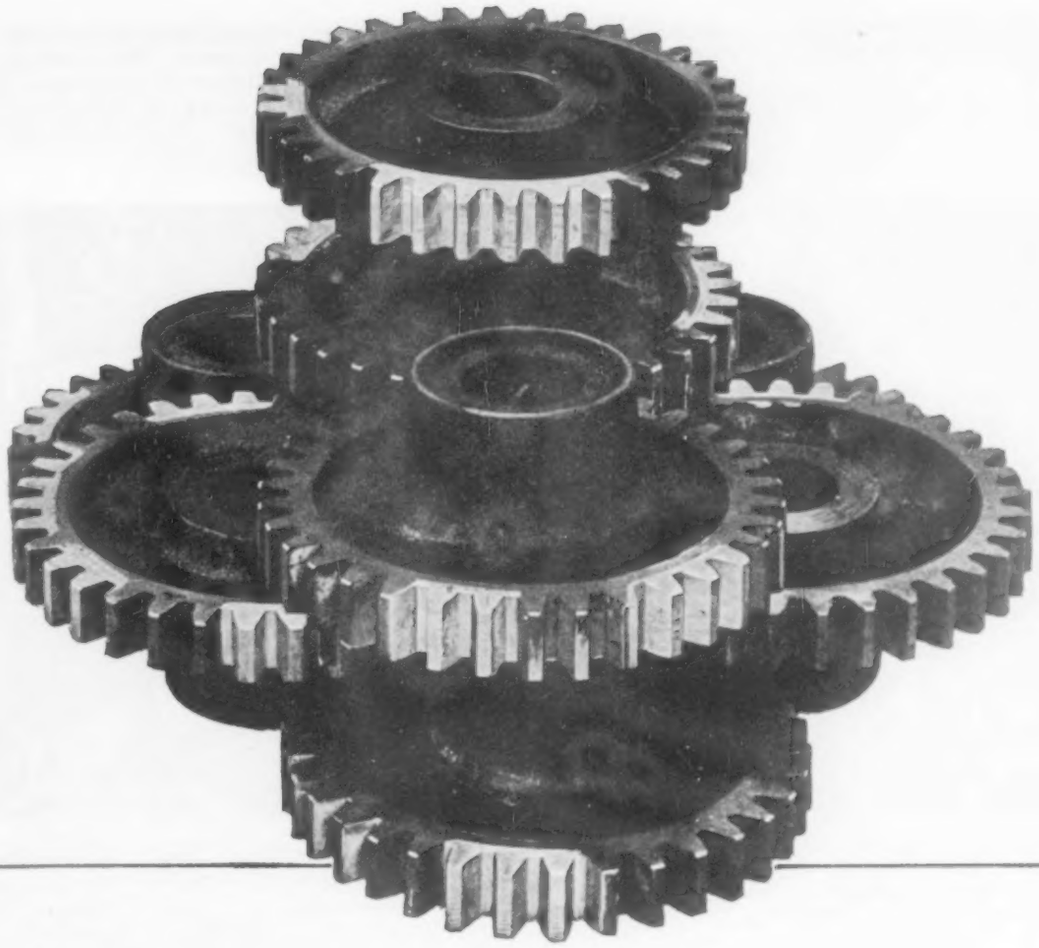
The various discussions were devoted to the determination of the most effective techniques for performing post war production and maintenance cleaning operations on a time-saving, low cost basis. Among the many subjects covered were the war-developed Oakite CrysCoat Process for providing tenacious paint adhesion to ferrous metal surfaces; preparation of aluminum and aluminum alloys for spot welding, Alroking, anodizing and other industrial finishes; surface preparation of basis metals before electroplating; use of Oakite materials in cutting, grinding, drawing, stamping, burnishing, tumbling, etc., and other important subjects.

NEW FOOT-OPERATED SPOT WELDER

In keeping with the recently announced Precision Rocker Arm air-operated spot welder, Precision Welder and Machine Co. of Cincinnati, Ohio, announces the new Precision Rocker Arm Foot-Operated Spot Welder. This machine overcomes the major objection to foot operation, lack of pressure, by a unique mechanism combining high pressures with minimum operator fatigue.

Among the features are:

1. High welding pressures up to 400 lb. on the electrodes with 50 lb. exerted by the operator.
2. Minimum foot treadle movement of $2^1/_2$ in. giving $1^1/_4$-in. electrode movement, also adjustable for best operating condition.
3. Unit construction with removable side covers keeps maintenance to a minimum.
4. Micro-switch firing of timer insures pressure before flow of weld current.
5. Fabricated frame of channel construction insures rigidity.



Eliminate down-time...

Weld Spare Gears with TOBIN BRONZE

READY TO GO to work again, these worn and broken gears from wire braiding machines at the Metal Hose Branch of The American Brass Company, were quickly and economically reconditioned with Tobin Bronze* Welding Rod.

Through the use of these spare gears, the machines were kept in operation 24 hours a day on vital work, braiding wire over flexible metal tubing for countless uses.

"Don't Scrap It . . . Bronze Weld It!" is more than a slogan—it's a NECESSITY in many plants. Publication B-13 describes Anaconda Welding Rods, suggests uses and procedures. Write for a copy. 4310 Rev.

*Reg. U. S. Pat. Off.

THE AMERICAN BRASS COMPANY
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

ANACONDA
from mine to consumer

BUY VICTORY BONDS . . . Help Assure World Peace

Anaconda Bronze Welding Rods

AUTOMATIC WELDING PROCESS INCREASES PRODUCTION 300%

Production has been stepped up 300% by replacing the former combination of mechanized and hand arc-welding procedures with the Unionmelt welding process by a manufacturer of water supply equipment. Superior appearance and improvements in weld quality have also been accomplished with the new automatic installation. The accompanying pictures illustrate the application of this welding process to the fabrication of a shutter-type strainer for use in deep water well pumps.

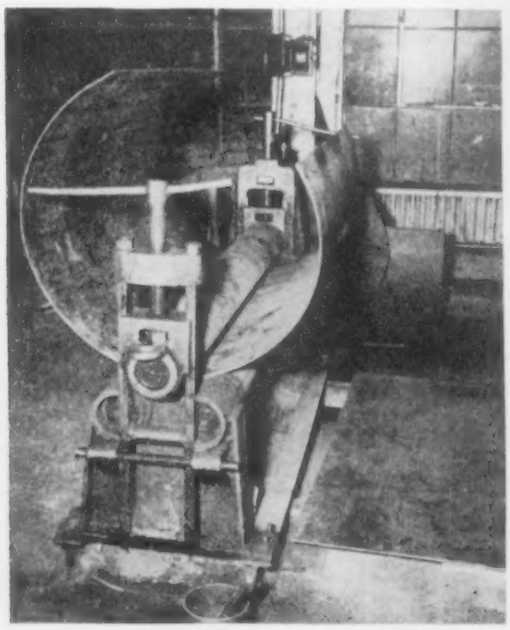


Fig. 1—The First Step in the Production of the Shutter Strainers Is the Forming of $^{3}/_{16}$-In. Ingot Iron Sheet Into Cylinders. The Longitudinal Seam Is Then Welded

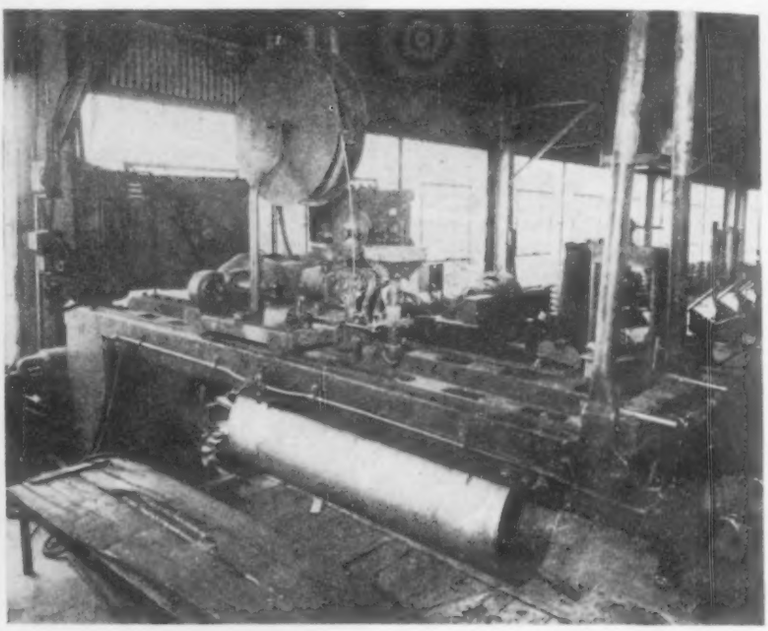


Fig. 2—A Rolled Form with the Joint Tack Welded Is Shown in Position for Making the Longitudinal Weld

This seam is welded by the Unionmelt process at a speed of 35 in. per minute. Previously this seam was arc welded using the automatic welding head shown here. With slight alterations the same head is now used for Unionmelt welding.

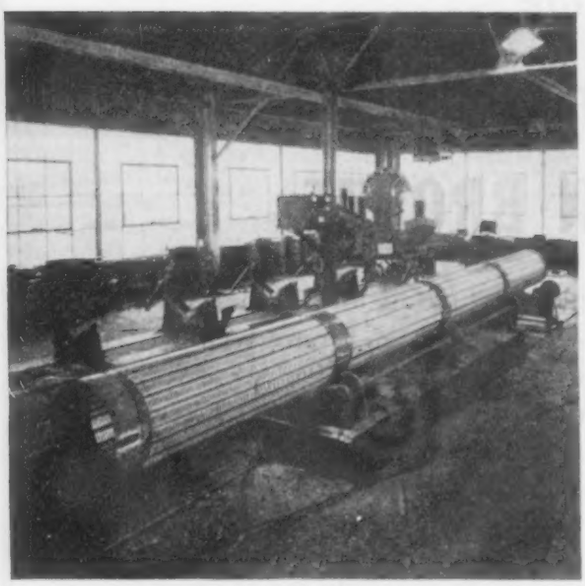


Fig. 3—When Several Such Cylinders Have Been Welded and Slotted They Are Joined Together to Make a Strainer Unit

To do this, connecting bands of the same material are fillet welded to the ends of each section. Formerly this procedure was a hand arc-welding job. With the new installation, the fillets are welded automatically while the assembly is rotated at a uniform speed on motor-driven rollers. The stationary welding head and rod reel are supported above the work by a pillar crane arrangement. A "melt recovery" unit, at right, is used to collect the unfused Unionmelt material for reuse.

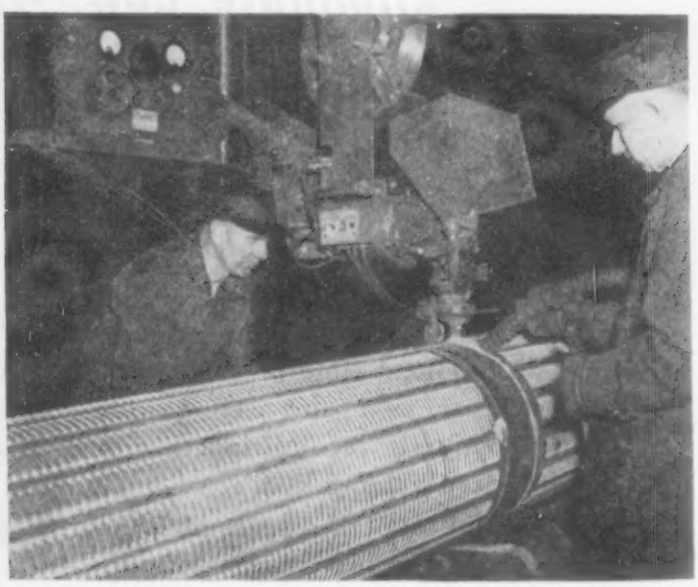


Fig. 4—The Unionmelt Type "U" Welding Head Is Used to Make the Fillet Welds on the Connecting Bands

The operator need wear no special equipment since the process is carried on without flash, spark or fumes. All necessary controls are concentrated on the welding head within convenient reach. Bare welding rod is pulled automatically by the welding head from the 25-lb. rod-reel appearing in the upper part of the picture. When the final Unionmelt fillet weld is made the strainers are ready for painting and shipment. Since Unionmelt welds are of excellent appearance and without spatter they require little or no cleaning.

Industry Endorses **EUTECTIC** Low Temperature WELDING RODS and FLUXES

WE DID THE IMPOSSIBLE AND JUMPED PRODUCTION 300% WITH *Eutectic*

Hother Andersen - Pres. - Ludlow Welding Co. STEEL FABRICATORS YONKERS, N. Y.

"In this type NNA WALKIE-TALKIE Case, all dimensions had to be held to extremely small tolerances of +.015 and −.000. Made of .042 cold rolled steel with water-tight joints, it posed a tough problem that was successfully solved by welding with EutecRod 16."

• Reg. U. S. Pat. Off.

EUTECTIC WELDING ALLOYS COMPANY
ORIGINATORS OF EUTECTIC LOW TEMPERATURE WELDING
40 Worth Street New York 13, N. Y.

"All attempts to produce this Walkie-Talkie Case by conventional drawing methods failed because the specified critical dimensional tolerances could not be held. When we were asked to tackle the job our engineers decided to try a new approach using welding. The cases were stamped from flat sheets and then formed into shape and the folded edges welded. Although this procedure enabled us to hold to required tolerances production with ordinary rods was too expensive. After three weeks of research we were ready to admit defeat when we tried EutecRod 16. *That solved our problem!*

"Due to close tolerance and thin gauge, heating had to be kept down to avoid distortion. Because EutecRod 16 bonds at 1300-1600° F. all danger of distortion was avoided.

"When we tried a standard steel rod our welders could only turn out 30 cases a day. But when they tried EutecRod 16 they jumped production 300% by producing 120 cases per day. This is the fastest gas rod they have ever used and practically eliminates after-machining.

"Thanks to Eutectic we were able to get into maximum production rapidly and economically."

All EUTECTIC Alloys are now available for civilian production. By means of 48 specially developed Rods and Fluxes you can employ the many revolutionary advantages of EUTECTIC *Low Temperature* Welding. Get the facts today!

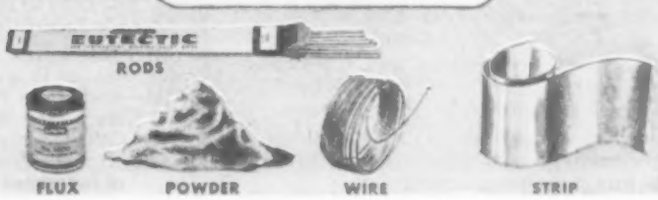
Please send me complete facts about EUTECTIC Rods and Fluxes and information on how to purchase a selection of the 9 most important EutecRods for every day use. Dept. JN-1

Name.....

Company.....

Address.....

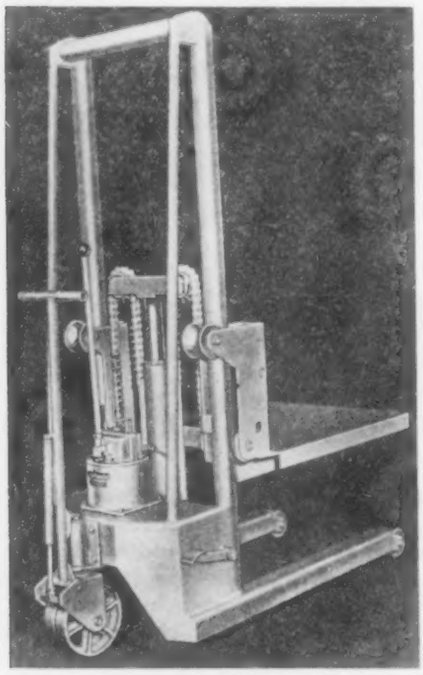
Castolin Eutectic



HYDRAULIC HIGH-LIFT TRUCK

Employing the same light-weight welded tubular and formed plate construction used in their 1000-lb. capacity unit, LYON-Raymond Corp., 2452 Madison St., Greene, N. Y., have added a 2000-lb. capacity Hydraulic High-Lift Truck to their line.

Its light weight—about one-third less than conventionally designed portable elevators—makes the truck very suitable for transferring materials as well as for stacking and tiering.



The standard stock model has a platform 30 in. wide by 36 in. long with an elevating range from 6 to 60 in. above the floor. Ease of movement is provided by Timken equipped 10 in. diameter front and 5-in. diameter rear wheels. A foot-operated floor lock, making two-point contact with the floor, will hold the truck firmly in position when desired. A two-speed hydraulic hand pump, as illustrated, is standard equipment or a motor-driven hydraulic pump may be furnished.

SPOT WELDING ACCELERATES TRYOUTS FOR NEW PRODUCTS

An illustration of how mass production methods such as spot welding with automatic or semiautomatic equipment can be employed during the reconversion months ahead to get certain types of products on the market economically and with much greater speed than has heretofore been possible is shown by a recent venture made by a Midwest cabinet manufacturer. With the aid of assembly spot welding, the company was able to have a trial lot of 5000 all-steel utility tables—for domestic, commercial and industrial uses—in the hands of the retailer within about five weeks' time after the project had been authorized, and without major investment in production equipment on the part of the manufacturer.

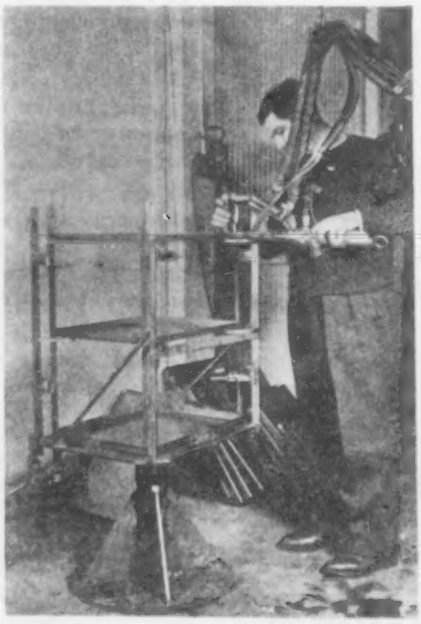
Portable gun spot welding—carried out in the job welding department of Progressive Welder Co., Detroit—was the fabricating method which permitted the production of the 5000 steel tables quickly and at a low cost per finished item.

The tables assembled by Progressive consist of four legs and three shelves each. All components are of 16-gage steel stampings. There are ten pieces, representing, however, only two different shapes, needed in the construction of each table. The simple sections requiring no expensive press dies are assembled with a total of 24 spot welds—two spots on each leg at each shelf. This fastening method is combined with interlocking of the members which thus produces exceptional strength and rigidity in the completed table.

A standard C-type portable resistance welding gun was used to make the spot welds. Only a single clamping type rotary work-holding fixture was necessary to complete the assembly of the tables.

A production speed of 16 tables per hour with one operator was easily attained, thus permitting the entire lot of 5000 units to be placed within the hands of the retailer some five weeks after the inception of the project.

This number of all-steel tables of one size is generally considered a high production run and normally involves considerable financial investment in dies, jigs and fixtures and other equipment with which to fabricate the units. Use of spot welding made possible the production of the 5000 tables at a minimum over-all cost and so permitted large-scale local sampling of the market for this particular item in a space of time generally held to be insufficient to make even a cursory market analysis.



Assembly Spot Welding of a 5000-Unit Lot of All-Steel Utility Tables for Market Tryout with a Progressive Welder Co. Portable Resistance Welding Gun and a Simple Clamp Type Work-Holding Fixture Enabled Completion of This High-Production Run in Five Weeks with a Minimum of Investment in Design

LINDE AND CARBIDE TO EXPAND SOUTHEASTERN FACILITIES

Plans for the construction of oxygen- and acetylene-distributing facilities in Mobile, Ala. and Miami, Fla., have been announced by The Linde Air Products Co., a unit of Union Carbide and Carbon Corp. Another unit, Carbide and Carbon Chemicals Corp., also has announced plans for the erection of a "Pyrofax" gas filling station at the Miami, Fla., site.

The Evans Construction Co. of Mobile, Ala., has been awarded the contract for constructing an oxygen filling station and an acetylene-producing plant in that city. The plans also include space for a warehouse for "Union" Carbide. Railroad service to the plant will be provided by a spur track from the Gulf, Mobile and Ohio Railroad. The plant is expected to be in operation about December 1st.

At Miami the construction contract has been awarded to John B. Orr, Inc. Facilities at this point will include an oxygen-distributing plant, an acetylene-producing plant and a warehouse for "Union" Carbide.

BOEDECKER APPOINTED WELDING ENGINEER

Woodrow Boedecker has been promoted to the position of Welding Engineer by The Bastian-Blessing Co. of Chicago, manufacturers of REGO welding and cutting equipment. He has been with the company for nine years, the last four of which he has served as Assistant Welding Engineer. In that capacity he was active

in the development of the Rego underwater cutting torch, new tips for welding torches and new lines of scarfing and gouging tips, as well as some of the special war equipment made by The Bastian-Blessing Co. Mr. Boedecker is a member of the AMERICAN WELDING SOCIETY.

Preferred by the *"Man on the Job"!*

OTHER McKAY MILD STEEL ELECTRODES	
McKay Grade	A.W.S. No.
No. 21	E4510
No. 3	E4520
No. 15	E6010
No. 17	E6012
No. 116	E6012
No. 16	E6020
No. 18	E6030
No. 16-H	None
No. 117	None
No. 19	None
No. 10	None
No. 713	E7010
No. 711	E7011
No. 713	None
No. 716	E7020

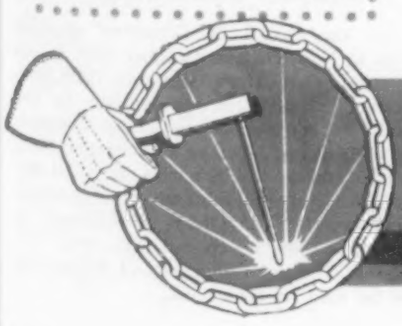
Because McKAY No. 14 is the *one* electrode which meets most welding rod requirements for maintenance, repair and operating—it has been popularly called the MRO Electrode by the man on the job.

The McKAY No. 14 Electrode is particularly suitable for factory maintenance. It operates with equal ease on either AC or DC machines. Even a relatively inexperienced welder does not have difficulty in getting excellent results.

But whether you require this mild steel electrode or any other of the wide range of mild steel, alloy steel and stainless steel electrodes—specify McKAY by name. The complete uniformity and successful performance of McKAY Rods under all work-uses make McKAY Welding Electrodes preferred by the "man on the job" as well as by the men who engineer the jobs.

Specifications:

McKAY No. 14 Mild Steel Electrode—Made to conform to the standards of American Welding Society's E1613 type of electrode. Made in sizes 1/16", 5/64", 3/32", 1/8", 5/32", 3/16", 7/32", 1/4" and 5/16".



GENERAL SALES OFFICES: YORK, PA.

THE McKAY COMPANY
PITTSBURGH, PA.

WELDING ELECTRODES . . . COMMERCIAL CHAINS . . . TIRE CHAINS

Boundaries Approved by Board of Directors

DISTRICT I

BOSTON SECTION

State of Vermont, State of Rhode Island, State of New Hampshire, State of Massachusetts from the Atlantic Coast Line to the Western Boundary of Worcester County.

BRIDGEPORT SECTION

Connecticut Counties of Fairfield, New Haven, Middlesex and New London.

CANAL ZONE

Not assigned—Section being abandoned.

NEW YORK SECTION

New York Counties of New York, Kings, Queens, Bronx, Richmond, Nassau, Suffolk, Westchester, Putnam, Rockland, Orange, and Sullivan and Greenwich Township in Fairfield County Connecticut.

HARTFORD SECTION

Connecticut Counties of Litchfield, Hartford, Tolland and Windham.

NEW JERSEY SECTION

All of New Jersey except the counties of Warren, Hunterdon, Burlington, Ocean, Camden, Atlantic, Gloucester, Salem, Cumberland and Cape May.

PORTLAND SECTION

The State of Maine.

NORTHERN NEW YORK SECTION

The New York Counties of Albany, Clinton, Columbia, Delaware, Essex, Franklin, Fulton, Greene, Hamilton, Herkimer, Montgomery, Otsego, Rensselaer, Saratoga, Schenectady, Schoharie, Ulster, Washington and Warren.

ROCHESTER SECTION

New York Counties of Orleans, Genesee, Livingstone, Onandago, Lewis, Seneca, Chenango, Oneida, Jefferson, Tompkins, Madison, Oswego, St. Lawrence.

WESTERN MASSACHUSETTS

All that part of the State of Massachusetts west of the western boundary of Worcester County.

WESTERN NEW YORK

New York Counties of Niagara, Erie, Chatagua, Cattaraugus, Allegheny, Wyoming and the Niagara Section of the Province of Ontario Canada.

DISTRICT II

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Pennsylvania: Bucks, Montgomery, Chester, Delaware, Philadelphia.
Delaware: New Castle.
New Jersey: Burlington, Ocean, Camdem, Atlantic, Gloucester, Salem, Cumberland, Cape May.

LEHIGH VALLEY SECTION

Pennsylvania: Northampton, Lehigh, Carbon, Monroe, Pike, Wayne, Lackawanna, Luzerne, Columbia, Schuylkill, Berks, Montour.
New Jersey: Warren, Hunterdon.

YORK SECTION

Pennsylvania: York, Lancaster, Dauphin, Adams, Franklin, Cumberland, Perry, Juniata, Mifflin, Snyder, Union, Milton, Northumberland, Lebanon.
Maryland: Washington.

MARYLAND SECTION

Maryland: Frederick, Carroll, Baltimore, Harford, Cecil, Howard, Anne Arundel.

WASHINGTON SECTION

Maryland: Montgomery, Prince George, Calvert, Charles, St. Mary's.
Virginia: Loudon, Fairfax, Prince William, Stafford, King George.
District of Columbia.

PORTSMOUTH SECTION

Virginia: Princess Anne, Norfolk, Nansemond, Lancaster, Southampton, Isle of Wight, Sussex, Surrey, Prince George, Charles City, James City, York, Warwick, Elizabeth City, New Kent, Gloucester, Mathews, Middlesex, Essex, King and Queen, King William, Westmoreland, Northumberland, Richmond.

DISTRICT IV

DETROIT SECTION

Michigan Counties of Wayne, Monroe, Washtenaw, Essex, Oakland, Macomb and all that territory within the Province of Ontario within 35 miles radius of Detroit City Hall.

FLINT SECTION

Michigan Counties of Gennesee, Bay Saginaw, Shiawassee.

COLUMBUS SECTION

Ohio Counties of Harden, Marion, Morrow, Knox, Coshocton, Guernsey, Licking, Delaware, Union, Champaign, Clark, Madison, Franklin, Pickaway, Fairfield, Hocking, Morgan, Muskingum, Noble, Washington, Athens and Logan.

PITTSBURGH SECTION

Pennsylvania Counties of Butler, Armstrong, Indiana, Cambria, Somerset, Westmoreland, Allegheny, Beaver, Washington, Greene, Fayette, and the West Virginia Counties of Hancock, Brook, Ohio and Marshall.

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CLEVELAND SECTION

Ohio Counties of Lorain, Cuyahoga, Lake, Ashtabula, Geauga, Medina, Summit, Portage, Stark, Wayne, Ashland, Richmond, Holmes, Tuscarawas.

SECTION WHOSE REPORTS ARE NOT IN

Grand Rapids, Erie, Cincinnati, Youngstown.

DISTRICT V

MILWAUKEE SECTION

The Ninth Federal Reserve District.

CHICAGO SECTION

Illinois Counties of Lake, Cook, DuPage, Kane, Kendall, Will, McHenry, Boone, Ogle, Winnebago, Lee, LaSalle, Grundy, Keekakie and the Indiana Counties of Lake, LaPorte, Porter and St. Joseph.

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INDIANA SECTION

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SECTIONS NOT SUBMITTED

Quad Cities, North Shore, Omaha and Louisville.

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120 BROADWAY, NEW YORK 5, N. Y.

ALBANY • CHICAGO • PITTSBURGH
SO. SAN FRANCISCO • TORONTO

MUREX *Electrodes*

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SECTION ACTIVITIES

BOSTON

The first meeting of the 1945–46 season was held at the Engineers' Club, Boston, on Monday, October 8th. Charles H. Jennings, of the Westinghouse Electric Corp., spoke on the subject of "Welding Distortion."

On behalf of the Boston Section, Chairman Peter E. Kyle presented a Past-chairman's pin to Frank W. Davis, who served as Section Chairman from 1943 to 1945.

CHICAGO

The following is a schedule of meetings of the Chicago Section. All meetings start at 7:30 P.M. and will be held in the People's Gas Auditorium, 122 So. Michigan Ave.

November 16th—"Resistance Welding in Modern Industry," Carl Otto, Douglas Aircraft Co., Inc.

December 21st—"Welding on the Railroad," Leland E. Grant, Chicago, Milwaukee & St. Paul R. R.

January 18th—"Arc Welding Practices," Carl M. Underwood, Northern Ordnance, Inc.

February 15th—"Thermit Welding," J. B. Tinnon, Metal & Thermit Corp.

March 15th—"The Welding of Copper and Copper Alloys," J. J. Vreeland, Chase Brass and Copper Co.

April 19th—"New Aspects of the Oxy-acetylene Processes," three speakers and Question Bee.

May 17th—"Power Supply for Resistance Welding," L. W. Clark, Detroit Edison Co.

CINCINNATI

The first of the 1945–46 meetings of the Cincinnati Section was held on September 25th in Middletown, Ohio. Through the courtesy of the United Welding Co. of Middletown, an inspection tour was conducted by L. T. Kenney, General Manager and Ed Wenzel, Superintendent, at 4:30 P.M. Sixty members enjoyed this tour and received first-hand information on the welding of numerous diversified weldments which this company produces.

At 6:30 P.M. 80 members were present at the Manchester Hotel for a chicken dinner and a short talk by Bennett Chapple of the American Rolling Mill Co. of Middletown. Mr. Chapple spoke of the uses of welding at their plants.

After dinner an inspection trip was conducted by Roy Freeze, General Works Manager, and Charles Stutenroth, Assistant Works Manager, through the central works of the American Rolling Mill Co. Of particular interest was the submerged arc welding of spiral pipe in various diameters and plate thicknesses.

CLEVELAND

David Dietz, Science Editor of the Scripps-Howard Newspapers, opened the 1945–46 session with a talk on "The Coming Era of Atomic Energy," at the first meeting of the Cleveland Section on October 10th.

Mr. Dietz, who is an internationally famous editor, has followed research in the field of atomic structure. Mr. Dietz analyzed atomic research and its meaning for the future of America and the world.

COLUMBUS

The October meeting of the Columbus Section was held on the 5th at Battelle Memorial Institute. W. J. Conley, Consulting Engineer of The Lincoln Electric Co., spoke on the subject "Fundamental Metallurgy as Related to Arc Welding." Movies on "The Prevention and Control of Distortion in Arc Welding" and "The Magic Wand of Industry" were shown.

DETROIT AND FLINT

By special invitation the American Institute of Architects, the American Society of Civil Engineers and the Associated Steel Fabricators of Detroit were invited to attend the Detroit Section meeting on Friday, October 12th, and the Flint Division on Thursday, October 11th, at which LaMotte Grover, Welding Engineer, Air Reduction Sales Co., New York, spoke on the subject, "Welded Prefabricated Steel Sections." Mr. Grover, with his wealth of experience in steel fabrication, presented a story that was more than interesting. It was directly educational.

A sound color film on "Prevention and Control of Distortion in Arc Welding" was shown through the courtesy of The Lincoln Electric Co.

The November meeting will be a joint meeting of the AMERICAN WELDING SOCIETY, Industrial Electrical Engineering Society of Detroit and American Institute of Electrical Engineers. It will be in the nature of a Resistance Welding Forum and will consist of afternoon and evening sessions.

INDIANA

The September meeting was held on the 28th at the Lincoln Hotel, Indianapolis. W. M. Woll, of the Commonwealth Edison Co., Chicago, addressed the meeting on the subject, "High Frequency, Induction and Dielectric Heating."

It was shown that any metal or electrical conductor can be heated by subjecting it to a high-frequency alternating magnetic field. Likewise, an electrical nonconductor, or dielectric, can be heated by placing it in a high-frequency electrostatic field. In practice this heating is accomplished rapidly, usually in a few seconds.

Since frequencies considerably higher than 60 cycles are required for these processes, it is necessary to use a converter to supply the desired high-frequency current. Four types of converters are available; motor-generator sets, spark gap sets, electron tube sets and the recently introduced rectifier sets. A wide range of frequencies can be used.

Several practical applications of induction heating are in use, an outstanding advantage being the reduction in heating or process time. Gears, crankshafts and other parts can be surface hardened to any desired depth by this means, the formation of scale being reduced by the shortened heating cycle.

Induction heating processes played an important part in war production in the manufacture of tin plate by an improved process that enabled the production of a threefold increase from a given amount of tin. It was also used in heating billets for making shells, and electrobrazing is still another application.

In the dielectric heating process frequencies up to 200,000,000 cycles per second are used. The material to be heated is placed between two electrodes, which may be flat plates or special shapes, depending on the application. Here again rapidity of heating is an advantage. This process will make it possible to make larger articles from thermosetting plastics.

The electronic sewing machine utilizes a pair of roll-type, high-frequency electrodes, making it possible to join sheets of plastic or plastic-impregnated cloth in the manufacture of such articles as leakproof rain coats.

It was also pointed out that high-frequency heating methods produce heat uniformly throughout the material.

The talk was illustrated with slides as well as several samples, which evoked an unusual amount of interest.

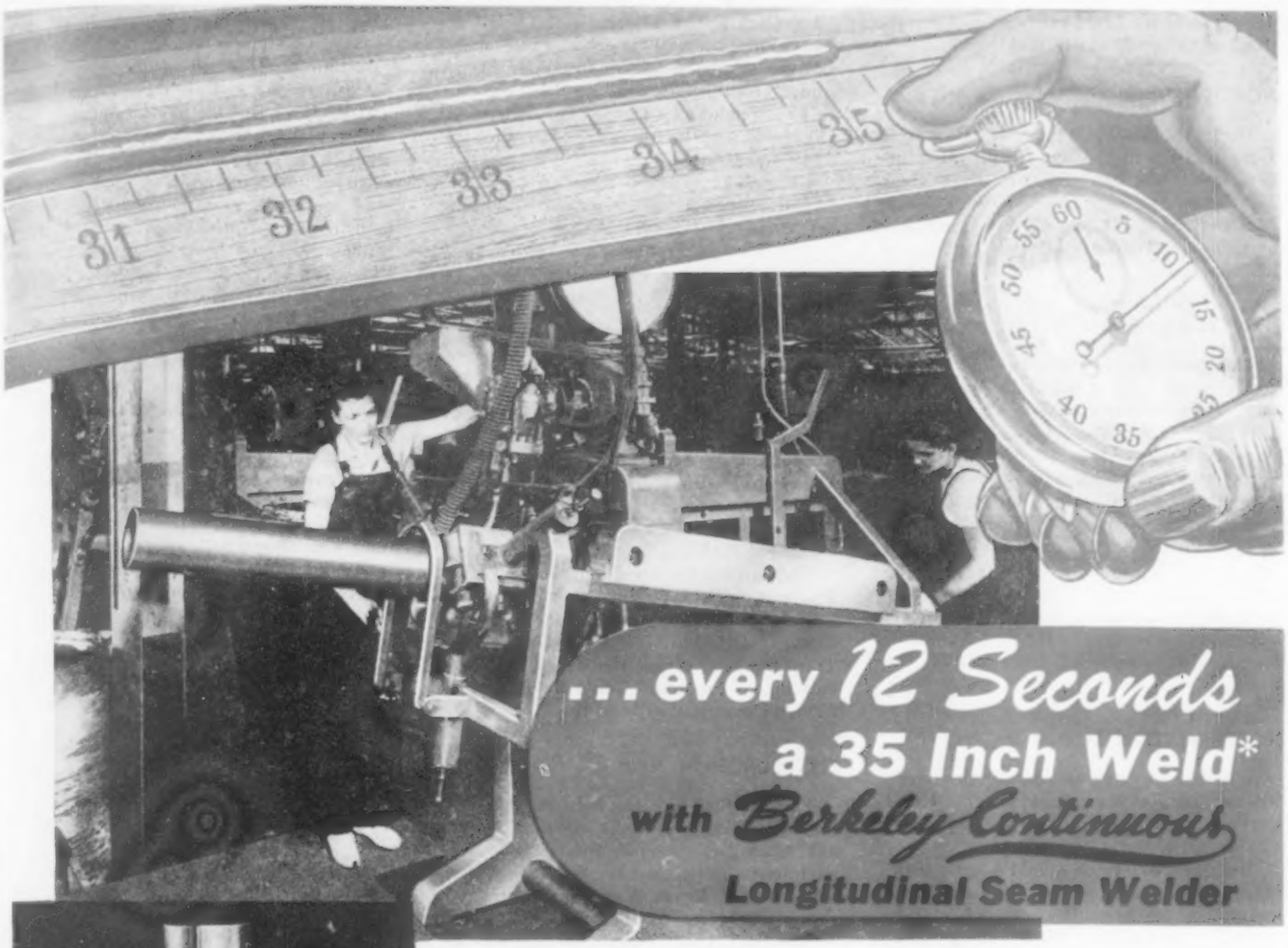
MARYLAND

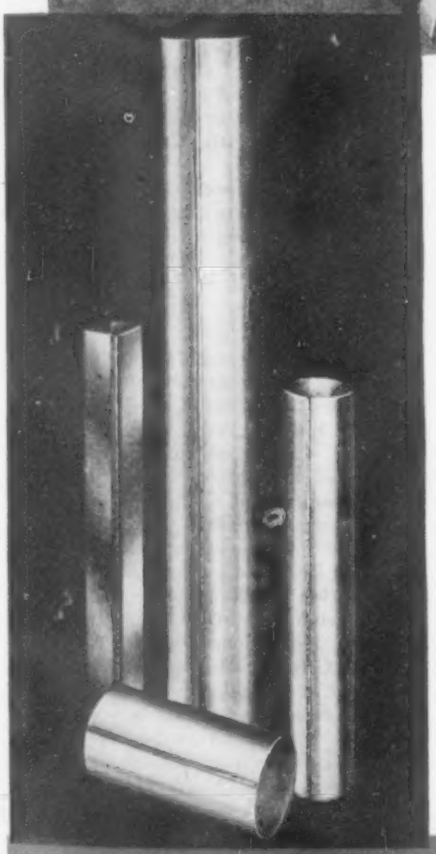
The first meeting of the season was held on September 24th and was preceded by a dinner at the Engineers' Club. A. R. Lytle, Research Laboratory, Union Carbide and Carbon Corp., presented an interesting address on "Modern Hard Facing Methods." Lively discussion followed.

A Question and Answer Period was inaugurated at this meeting, starting at 7:30 P.M. Considerable interest was evinced by participants and audience.

NEW JERSEY

A. R. Lytle, of the Union Carbide and Carbon Corp., was the guest speaker at the September 18th meeting of the New





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DANVILLE, ILLINOIS

Jersey Section. Mr. Lytle's subject was on "Oxyacetylene Pressure Welding."

NORTHWEST

D. C. Smith, Metallurgist, Electrode Division, Harnischfeger Corp., Milwaukee, spoke on "Electrode Coatings, Their Development and Their Effects Upon Welding" at the October 3rd meeting held at Coffman Memorial Union, University of Minnesota.

NEW YORK

The New York Section celebrated its 25th Anniversary at a Dinner Dance held at the Hotel Pennsylvania on the evening of October 18th. The evening was selected to coincide with the one-day Annual Meeting of the AMERICAN WELDING SOCIETY. Some 600 members, their guests and wives attended the dinner, which was a gala affair. Preceding the dance there was a half-hour talk and demonstration on Splitting the Atoms and Atomic Energy" by John R. Dunning of Columbia University. Dr. Dunning was the first American scientist to accomplish successfully the fission of the uranium atom.

NORTHWESTERN PENNA.

A dinner meeting of the Northwestern Penna. Section was held at the Hotel Corry, Corry, Pa., on Wednesday, September 12th.

As a result of balloting held August 10th, it was reported the following officers were unanimously elected:

Chairman, C. W. Lytton; *Vice-Chairman*, W. H. Cochran; *Secretary-Treasurer*, W. R. Boyd.

Because of the desirability of having an Executive Committee which could function immediately, it was decided, after thorough discussion of the subject, that nomination and election be held of one member to hold office for two years and two members to hold office for one year. These gentlemen, together with the elected officers of the Section, are to constitute the Executive Committee, until their successors are chosen in accordance with the By-laws:

H. O. Walker, two-year term; L. H. Johnson and S. V. Williams, one year term.

The Chairman announced the appointment of the following committees:

Temporary Program Committee: W. H. Cochran, *Chairman*, Ed. J. Brown, Hamilton W. S. Trayer, H. O. Walker, S. V. Williams.

Temporary Membership Committee: Daniel H. Meyers, *Chairman*, Harold Maeder, E. N. Chester, J. C. Hobbs, T. J. McNamara, Carl Jensen, A. E. Drum, E. R. Torgler.

Advertising Committee: Ed J. Brown, *Chairman*, C. V. Boyer, Paul Ristau.

OKLAHOMA CITY

Ernest Bernard, Plastics Development Engineer, representing Chicago Molded Products Corp., Synthane Corp. and Iten Fiber Co. of Illinois, was the guest speaker at the October 4th meeting held at the Biltmore Hotel. Mr. Bernard's subject, "Development of Plastics and Their Uses in Welding," was a timely and interesting outline of the discussion on Plastics. A film, "Modern Plastics," was also shown.

The Oklahoma City Section announced the election of the following officers for the 1945–46 season:

Charles M. Bowen, *Chairman;* Joseph M. Mideke, *Vice-Chairman*; L. L. Stewart, *Secretary;* Denver House, *Treasurer.*

Executive Committee for two years: Adolph C. Echer, Jim Craig, Howard Sims, Luther Cold, William Klein (one year).

PHILADELPHIA

A. C. Weigel, President, AMERICAN WELDING SOCIETY, and Vice-President, Combustion Engineering Co. Inc., New York, was the guest speaker at the October 15th meeting held at the Engineers' Club. Mr. Weigel spoke on the "Present and Future of Welding."

The second Group Discussion meeting was held on Friday, November 2nd, at the Engineers' Club Junior Room. W. A. Reeves of John A. Roebling Sons Co., Trenton, N. J., was the director of the meeting. "Pro's and Con's of Welding in Bridge Construction" was the subject.

PITTSBURGH

The October meeting held on the 17th was addressed by Scott D. Baumer, Assistant Manager, Applied Engineering Department, Air Reduction Sales Co., New York, who spoke on "Various Welding and Cutting Probelms in Heavy Industry."

The 25th Anniversary Meeting will be held on November 21st at the Imperial Room, Webster Hall Hotel, Oakland. The principal speaker will be A. Allen Bates, Manager, Chemical and Metallurgical Department, Westinghouse Electric Corp., whose subject will be "Observations of Postwar Germany."

Program of coming meetings is as follows:

January 16th—"Brazing," Arthur K. Phillipi, Manufacturing Engineer, Westinghouse Electric Corp.

February 20th—"Design for Welding," Fred L. Goldsby, Development Engineer, Chicago Bridge and Iron Co.

March 20th—"Welding as a Maintenance Tool," J. B. Whitlock, General Maintenance Engineer, The American Rolling Mill Co.

April 26th—Ninth Annual Tri-State Convention. Special program of speakers and activities will be announced later.

All of the above meetings with the exception of the Anniversary Meeting, will be held in the Auditorium, Mellon Institute of Industrial Research, Oakland.

The officers for 1945–46 are as follows:

Chairman, G. O. Hoglund, Aluminum Co. of America; *Vice-Chairman*, Harry P. Schane, Allis Chalmers Mfg. Co.; *Secretary*, J. F. Minnotte, Minnotte Brothers Co.

PORTLAND

The fourth meeting of the Portland Section was held in the Congress Hotel on Tuesday, September 25th. A dinner was enjoyed by 40 members and guests.

Arthur R. Hard, Research Engineer of the Industrial Research Division, Washington State College, Pullman, Washington, explained the reasons for the equipment at the college, stating that it was for experimental purposes and tests would be made for any manufacturing company, figuring expense costs of production, etc.

The speaker of the evening, J. H. Cooper, Chief Sales Engineer for the Taylor-Winfield Corp., Warren, Ohio, talked on "Possibilities in the Field of Resistance Welding."

Mr. Cooper covered the resistance welding field through spot, flash, butt and seam welding with many variations. He pointed out the many uses made of spot welding during the war and the many applications now open for the manufacturers in peacetime.

Slides of specific machines and applications were shown following the talk.

The questions and answers discussion covered many interesting problems.

ROCHESTER

Officers for 1945–46 season are: *Chairman*, Walter Dick, Odenbach Shipbuilding Corp.; *Vice-Chairman*, Joseph O'Rorke, Eastman Kodak Co.; *Secretary*, Edward R. Jones, Seneca Steel Service, Inc.; *Treasurer*, Harold J. Kinz, The Anstice Co. Inc.

SAN FRANCISCO

Lt. R. S. Hale, U.S.N.R., Project Manager of Construction Contracts at U. S. Naval Drydocks, Hunters Point, Calif., spoke on "Welded Steel Construction of Buildings and Other Steel Structures" at the September 24th meeting held at the Engineers' Club.

After the main portion of the meeting, a sound motion picture, provided by the War Department and entitled "Two Miracles," was shown.

SYRACUSE

The ninteenth regular meeting of the Syracuse Section was held September 12th in Room 19 of the College of Applied Science Building, Syracuse University.

W. J. Conley of the Lincoln Electric Co. was introduced by the Technical Chairman, Robert Greer, and gave a very interesting discussion on "Stresses and Strains." This was accompanied by a Lincoln Electric Co. motion picture, "The Prevention and Control of Distortion in Arc Welding." Mr. Conley answered a number of questions posed by the audience.

Mr. Greer headed a discussion as to whether it should be the policy of the Syracuse Section to bring before its members at regular meetings new products which have been placed on the market. There was some question as to whether this would be considered free advertising. It was the opinion of those present that the Section should take every opportunity to place this information before its members. The question was brought up because of the fact that the Bentley Weldery had on exhibit in the hall their newest idea in positioning equipment.

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There were 26 members and 8 guests present. Meeting was adjourned by the Chairman at 10:15 P.M.

TOLEDO

Newly elected officers of the Toledo Section are as follows:

Chairman, Edwin Nafzger; *1st Vice-Chairman*, John C. Geisland; *2nd Vice-Chairman*, Sam W. Snell; *Secretary-Treasurer*, A. H. Homrighaus, Jr.

Members-at-Large, Anthony Menna, L. W. Masters, Harold A. Smith; *Chairman, Membership Committee*, Anthony Menna; *Chairman, Program Committee*, John C. Geisland; *Chairman, Problem Committee*, Sam W. Snell; *Delegates to Toledo Technical Council*, C. M. Richardson, Edwin Nafzger.

WESTERN MASS.

A joint meeting with the American Society for Metals, Springfield Chapter, was held on September 17th at the Hotel Sheraton, Springfield, Mass. Carl G. Johnson, Worcester Polytechnic Institute, gave a very interesting talk on the fundamentals of welding and welding metallurgy. In addition to Prof. Johnson's talk, there was a showing of the moving picture, "Magic Wand of Industry," in technicolor, through the courtesy of The Lincoln Electric Co.

Program of coming meetings is as follows:

November 19th—"Hard Facing," speaker to be contacted.
December 17th—"Furnace Brazing," Mr. Webber, General Electric Co.
January 21st—"Casting Repair," Vincent Malcolm, Chapman Valve Co.
February—"Welding Design," C. H. Jennings, Westinghouse Electric Corp.
March—"Resistance Welding," J. H. Cooper, Taylor-Winfield Corp.
April—"Heliarc Welding."
May—"Atomic Arc Welding."

WESTERN MICHIGAN

The first meeting of the season was held on Monday, September 24th, at the Southern Barbeque in Grand Rapids. A real chicken dinner served "country style" preceded the meeting. W. C. McLott of the Resisto Loy Co. gave a very excellent talk on "Hard Facing." His subject was well covered with technical information and practical illustrations.

It is the intention of the Program Committee to schedule programs on resistance welding and gas welding and brazing of cast iron at some early dates.

YORK-CENTRAL PENNSYLVANIA

E. B. Van Sant, General Manager, Riley Stoker Co., Badenhousen Division, was the guest speaker at the October 3rd meeting. His subject was "Welding of High Pressure Boilers."

Program of coming meetings is as follows:

December 5th—"Eutectic and Low Temperature Welding," R. D. Wasserman, President, Eutectic Welding Alloys Co., New York City.

January 2nd—"Welders Forum," Technical committee—York A.W.S. General discussion of welders' everyday problems.

February 6th—"Forming and Bending Metals," R. M. Dennis, Assistant to President, By-Products Steel Corp., Coatesville, Pa.

March 6th—"Resistance Welding," G. N. Sieger, President, S.M.S. Corporation, Detroit, Mich.

April 3rd—"An Evening of Entertainment." Annual Dinner—Ladies' Night. May 1st—Coatesville Meeting. Guests of Lukens Steel Co. Members only.

Meetings are held in Engineering Bldg., 26 S. Beaver St., York, Pa.

New Members

September 1 to September 30, 1945

BOSTON

Harvey, Francis S. (B), Albert J. Daniels, Engineers & Builders, 661 Main St., Shrewsbury, Mass.

CHATTANOOGA

O'Neal, James Wm., Sr. (C), 2408 Vance Ave., Chattanooga 4, Tenn.

CHICAGO

Allen, John W. (B), 11121 Longwood Dr., Chicago, Ill.
Arnold, Perry Charles (B), Chicago Bridge & Iron Co., 1305 W. 105th St., Chicago, Ill.
Christofferson, Le Grand (B), 9515 So. Seeley Ave., Chicago, Ill.
Hillyer, Glenn (C), Chicago Rivet & Machine Co., 25th Ave., Bellwood, Ill.
Moyer, Fred (B), Chicago Bridge & Iron Co., 1305 W. 105th St., Chicago, Ill.
Steczynski, Myron E. (B), The Bastian Blessing Co., 4201 Peterson Ave., Chicago 30, Ill.

CINCINNATI

Setzler, Paul H. (B), 403 So. D St., Hamilton, Ohio.

DETROIT

McCarroll, R. H. (A), Ford Motor Co., 3000 Schaefer Rd., Dearborn, Mich.
Richter, Carl E. (C), 7744 Phelps Ave., Detroit 13, Mich.

LOS ANGELES

Dow, Ed. (C), 217 Ave. G., Redondo Beach, Calif.
Frost, Donald E. (C), Lockheed Aircraft Corp., Burbank, Calif.
Hughes, Paul B. (C), Soto Welding & Mfg. Co., 1708 So. Soto, Los Angeles, Calif.
Mills, Thomas (C), 209 W. First St., San Pedro, Calif.
Stephan, Dean E. (B), Chicago Bridge & Iron Co., 608 South Hill St., Los Angeles 14, Calif.

MARYLAND

Blenckstone, F. E. (B), Maryland Oxygen Co., Div. of National Cylinder Gas Co., 1700 S. Newkirk St., Baltimore, Md.
Gilbert, Jr., John H. (C), 30 Compass Rd., Baltimore 20, Md.
Greb, Charles W. (C), Northwind Rd., R. F. D. 6, Towson 4, Md.
Grove, Charles E. (C), 664 Broadway, Hanover, Pa.
Thompson, Henry J. (C), 287 E. Hillside Terrace, Brooklyn Heights 25, Md.

MILWAUKEE

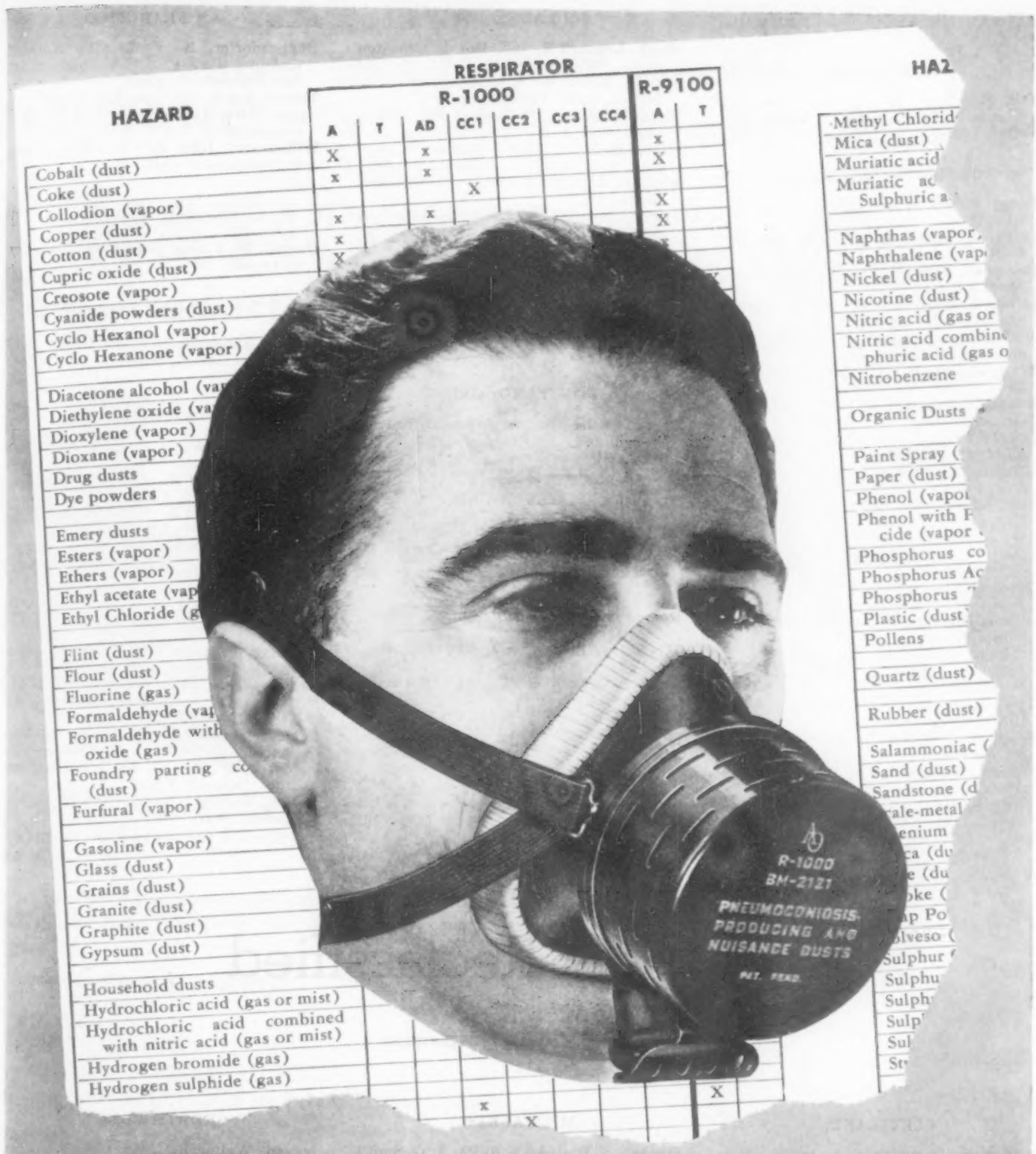
Bybee, J. K. (C), Ampco Metal, Inc., 1745 So. 38th St., Milwaukee, Wis.
Sorensen, E. J. (C), Ampco Metal, Inc., 1745 So. 38th St., Milwaukee, Wis.

NEW JERSEY

Coffin, John E. (B), 12 Oakland Terrace, Maplewood, N. J.
Dyer, John D. (C), 33 Leland Ave., Plainfield, N. J.
Garrabrandt, Charles E. (C), Essex Welding Equip. Co., 40 Van Buren St., Newark 5, N. J.
Helgeman, Arthur (C), 146 18th Ave., E. Patterson, N. J.
Rowles, Robert (C), 232—40th St., Irvington, N. J.

NEW YORK

Di Nardo, Anthony (B), 33 Burke Ave., Hempstead, N. J.
Dunn, Joseph C. (C), 475 Bronx River Rd., Yonkers 4, N. Y.
Macneal, Le Roy C. (B), 200 N. Border



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Wolter, Lester C. (B), Wyoming, Minn.

NORTHWESTERN PENNA.

Brong, Alfred (C), 1232 W. 11th St., Erie, Pa.
De Frees, Joseph H. (C), 316 Pine St., Warren, Pa.
Hammond, Richard (C), 460 E. Main St., Bradford, Pa.
Knibbs, Fred H. (C), 408 N. Washington St., Titusville, Pa.
Lauffenburger, Leuis P. (C), 12 N. Kendall Ave., Bradford, Pa.
Marsh, Louis H. (C), 109 Hess Ave., Erie, Pa.
McAuliffe, Robert L. (C), 41 N. Main St., Greenville, Pa.
Ostberg, Irwin C. (C), 518 Smithson Ave., Lawrence Park, Erie, Pa.
Patterson, Archie A. (C), 1213 E. 20th St., Erie, Pa.
Peck, John L. (C), R. D. 1, Harborcreek, Pa.

PEORIA

Czyzewski, Harry (C), 315 Barker Ave., Peoria 5, Ill.
Guthrie, Bradford (C), 1325 So. Jefferson, Peoria, Ill.
McSimor, Daniel (C), Keystone Steel & Wire Co., 126 W. Moreland Ave., Peoria, Ill.
Myers, Lester R. (C), 805 Kettelle, Peoria, Ill.
Oldendorph, Walter L. (C), 719 Winim St., Peoria, Ill.
Schaer, Fred Charles (C), 1532 Lincoln Ave., Peoria, Ill.
Stine, Donald L. (C), 1411 N. Monroe, Peoria, Ill.

PHILADELPHIA

Black, Leonard R. (C), Box 3, Cranston Hgts., Wilmington 126, Del.
Dusett, Ralph S. (C), 546 Broad St., Station Bldg., Philadelphia, Pa.
Ficchi, R. F. (C), 16 Central Ave., Hammonton, N. J.
Gibbs, H. R. (C), Lloyds Register & Shipping, 1600 Arch St., Philadelphia, Pa.
Maillart, Edmond B. (B), P. O. Box 542, Media, Pa.
Tegler, Maurice B. (C), 546 Suburban Station Bldg., Philadelphia, Pa.

PORTLAND, ME.

Brown, Odber C. (C), 10 Park Pl., Portland 3, Me.
Sorenson, Roland L. (C), R. F. D. 6, Portland, Me.

PORTLAND, ORE.

Cox, Elton Lee (B), c/o American Bureau of Shipping, 722 Board of Trade Bldg., Portland 4, Ore.

PUGET SOUND

Sherman, Charles S. (C), 1728 Winfield Ave., Bremerton, Wash.

ROCHESTER

Kobus, Edward (C), 47 Fuller Ave., Webster, N. Y.
McCaffery, Edward (C), 130 Park Ave., Brockport, N. Y.
Richens, Merrill E. (C), 54 Steko Ave., Rochester 13 N. Y.
Tuccio, Manuel J. (C), 131 Central Park, Rochester 5, N. Y.

ST. LOUIS

Schroeder, Wm. (C), Socony Vacuum Oil Co., South 20th St., East St. Louis, Ill.

SAN FRANCISCO

Deggendorfer, N. V. L. (B), National Cylinder Gas Co., 326 Howard St., San Francisco 5, Calif.
Robley, Asa A. (B), Palo Alto, Calif.
Sando, Peter J. (B), 841—47th St., Oakland, Calif.
Williamson, John X. (B), 3818 Clarke St., Oakland 9, Calif.

SOUTH TEXAS

Harrell, W. L. (C), 3311 Ozark, Houston 4, Texas.

WESTERN MASS.

Deliso, Banjamin (C), 46 Forest Park Ave., Springfield, Mass.

WICHITA

Beeman, H. W. (C), 1360 Perry St., Wichita 3, Kan.
Hughes, Delbert E. (C), 644 No. Crestway, Wichita 6, Kan.
Nelson, Herschel E. (C), P. O. Box 2108, No. Wichita Sta., Wichita, Kan.
Sutton, O. A. (A), The O. A. Sutton Corp., 403 Beacon Bldg., Wichita, Kan.

NOT IN SECTIONS

Dowding, Frederic C. (C), 96, Mudford Rd., Yeovil, Somerset, England.
Kemp, W. N. (B), Wingfield—35th St. John's Rd., Cosham, Portsmouth, Hants, England.
Regle, Maurice (C), Sciaky Sa, 13 Rue Charles Fourier, Paris 13, France.
Robinson, W. H. (B), 534 Irwin Keasler Bldg., Dallas 1, Texas.
Wilson, Harvey (C), 408—6th St. S. W., Canton, Ohio.

Members Reclassified

During Month of September

CLEVELAND

Crittenden, Percy (from C to B), Stop 47½ Broadway, Lorain, Ohio.
Douglas, W. R. (from C to B), The American Shipbldg. Co., Foot of West 54th St., Cleveland, Ohio.
Midnight, S. A. (from C to B), American Shipbldg. Co., 1410 Terminal Tower, Cleveland, Ohio.
Steinman, J. E. (from C to B), American Shipbldg. Co., 1410 Terminal Tower, Cleveland, Ohio.

HARTFORD

Newton, Payson T. (from D to C), 120 Winthrop St., New Britain, Conn.

LOS ANGELES

Gray, Albert (from D to C), 648 E. 77th St., Los Angeles, Calif.

MILWAUKEE

Owings, S. B. (from C to B), A. O. Smith Corp., Weld Rod Sales Dept., Milwaukee, Wis.

NEW JERSEY

Buczkoski, Bernard (from C to B), 1064 Chester St., Hillside, N. J.
Gunning, John E. (from C to B), 75 Woodbine Ave., Newark, N. J.
Kreisel, Otto (from C to B), 59 Elmwood Terrace, Irvington, N. J.
Miller, R. C. (from C to B), 122 Clinton Ave., Newark, N. J.
Swankhous, F. B. (from C to B), 48 Ivy St., Newark, N. J.

NORTHERN NEW YORK

Boswell, Edmund N. (from C to B), 1087 Regent St., Schenectady, N. Y.

NORTHWEST

Jansen, Walter R. (from C to B), 1655 Juliet Ave., St. Paul 5, Minn.

PEORIA

Maddox, Emett S. (from D to C), 601 W. Reservoir Blvd., Peoria 4, Ill.

PHILADELPHIA

Behmke, Wm. (from D to C), 1018 Washington Ave., Woodbury, N. J.

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Smith, Wilbur C. (from C to B), 1843 N.E. Bell Dr., Portland, Ore.

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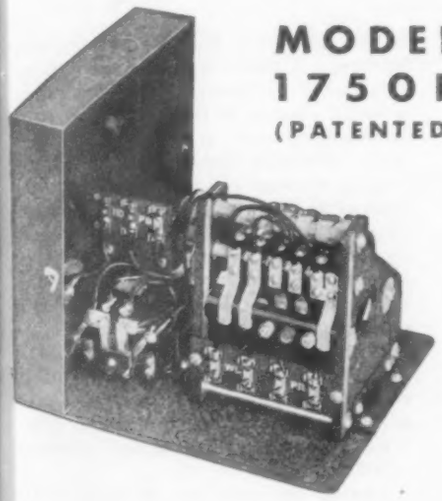

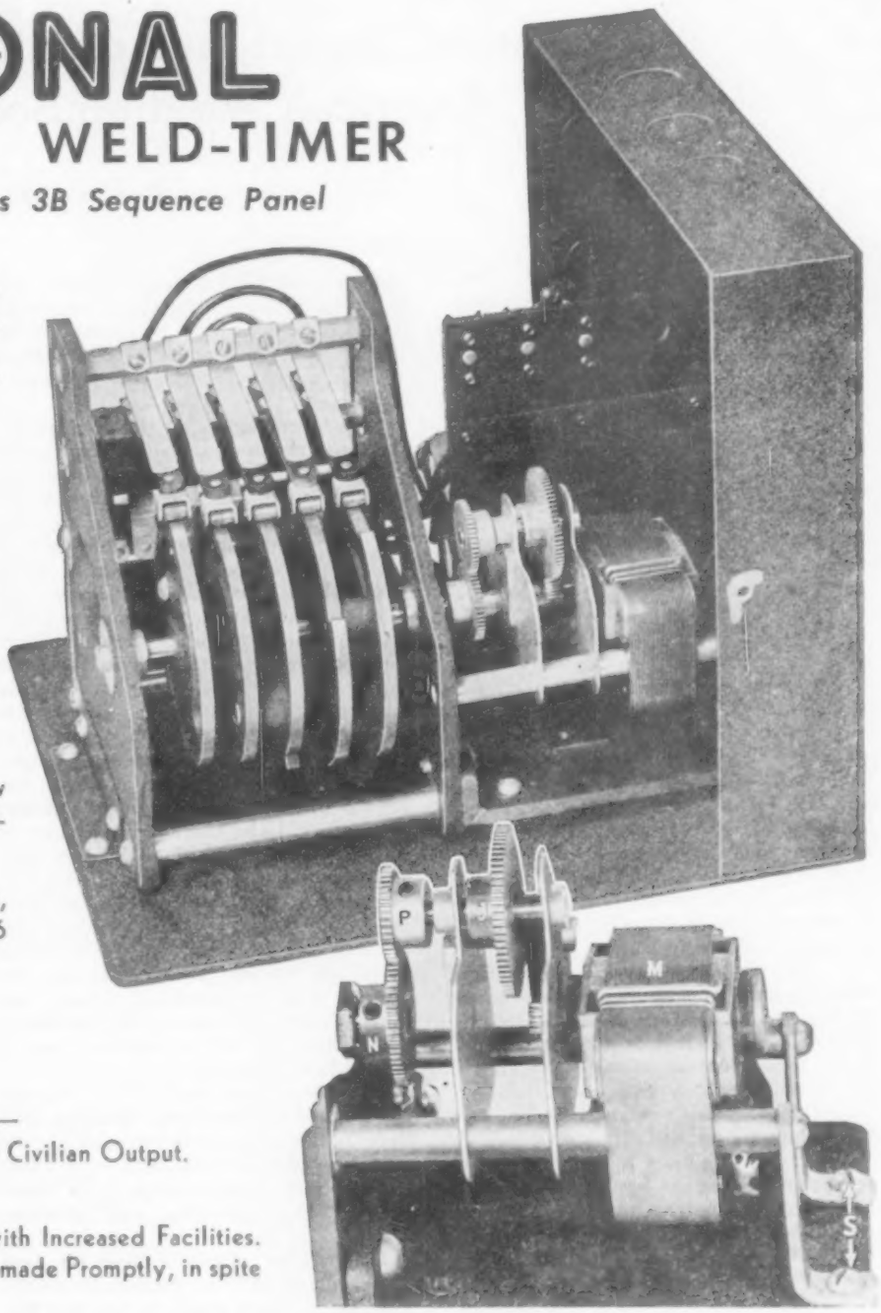

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WASHINGTON, D. C.

Darcey, James F. (from C to B), 4421 Warren St., N. W., Washington, D. C.

YORK-CENTRAL PENNA.

Knote, Harry E. (from D to C), Milroy, Pa.

NOT IN SECTION

Kelly, Lawrence L. (from D to C), 4 Bright St., Oakwood Subdivision, Savannah, Ga.

Annual Report on Activities of the American Welding Society

Year Ended September 30, 1945

PRESIDENT'S ADDRESS TO THE MEMBERS OF THE AMERICAN WELDING SOCIETY

Annual Meeting—1945

By A. C. Weigel

IT is unfortunate that the members of our Society, having taken such a prominent part in the war activities, are not able, after the cessation of hostilities, to hold a large convention. Needless to say, in order to facilitate getting our boys home, who have done such a wonderful job in the field, we have had to forego a large convention and exhibit this year.

The young men in the military organizations of this country have performed an unprecedented feat in overcoming the forces of militarism. All honor is due them, but I also feel that the members of the American Welding Society, and the results of its work, have played an important part in the victory over Hitler and Hirohito.

The development of welding and the research carried on in welding have made possible, in the required time, the production of airplanes for transportation, bombing and the protection of our troops, of ships in an unthought-of number for the transportation of fuel, food, supplies and men, armaments of all sizes, small to large, tanks, mobile equipment, landing ships, floating drydocks and, above all, battleships and aircraft carriers.

Welding, as we know it today, was first recognized during the last war, and starting from nothing, limited results were accomplished. The realization on the part of a small group that welding had a great future, prompted them to organize the American Welding Society 26 years ago. They fostered experimental work, education and the promotion of welding to the extent that we were ready to accomplish real results when this great crisis arose. They were ready to put their shoulders to the wheel and go many steps further after the beginning of the crisis. These same pioneers, most of whom are with us today, have every right to feel as proud as the most prominent members of our armed forces.

The Society has had a successful year. We have had a large increase in membership, a great deal of activity among our members, Sections, and technical and other committees. However, it has been unfortunate that due to travel restrictions it has been impossible for the officers to visit as many Sections as was anticipated.

It is my opinion that the Society has before it the biggest job in its history. Under the exigencies of war, almost any class of work has been accepted, much of it without regard to cost. We are now entering the peacetime period, which will require more careful and exact work. Much of the class of work which has been allowed in the last few years must of necessity be improved upon. The members of our Society are going to have to carry on much more research work to develop methods of production and procedure to improve our product. The excuses of emergency cannot be tolerated any longer. This period of emergency, however, has proved to us that there is much desired information to be sought for and a lot of research work required. We need more study as to the proper materials for successful and correct fabrication, we need more information in the handling and preparing of our material for welding, more information as to methods for proving that the resulting product will fill the required purposes with reasonably sure safety and with a minimum use of material and manhours.

The Officers and Staff of The Society have served faithfully and efficiently, and have been instrumental in placing the American Welding Society on a sound basis, so that it will continue to be one of our leading engineering and technical societies.

To the new officers I give my best wishes, particularly to the new President, who has done so much in the last few years in guiding research work.

SUMMARY OF ACTIVITIES OF THE AMERICAN WELDING SOCIETY

For Year Ending September 30, 1945

By M. M. Kelly, *Secretary*

The fiscal year just finished has been one of considerable advancement in the activities of our Society, as can be seen from reports that follow. The Society is now 26 years old. It has over 8000 members, is sound financially, and it has established itself as an organization serving a useful purpose in industry. Like other technical societies, it has concerned itself with promoting the science and art of welding through meetings of the National Society and Sections, through its publications—The Welding Journal, *Welding Handbook* and other educational books; through its standardization and educational work; and its cooperative research on important problems which arise in the application of welding. Having done its part in the war effort for which it has received due recognition, the Society's activities are now turned on aiding industry in reconversion and general peacetime activities.

During the year five meetings of the Board of Directors have been held, one in Cleveland and four in New York. In addition, the Executive Committee held one meeting in New York. These meetings dealt primarily with the establishment of policies and improvements in the Society's operations toward the end of increasing its usefulness to its members and industry.

This past year the By-Laws Committee completed a comprehensive revision of the By-Laws and Rulings of the Board of Directors, which had been started during the previous administration when it became apparent that the growth of the Society and the great expansion of its activities in the intervening years since its organization, called for such change. The revised edition, after review by the Sections, was approved by the Board of Directors at its meeting on December 15, 1944. It was submitted to the voting membership of the Society and stands approved as of August 1, 1945. At its meeting on June 28, 1945, the Board approved two additional amendments providing for the appointment of an Honorary Membership and Honorary Directorship Committee and additional members on the Awards Committee for specific purposes. These will, in due course, be submitted to the voting membership.

The By-Laws Committee's recommendation for the deletion of Article VII, "Expulsion of Members," as part of the Constitution and the incorporation of this Article in the By-Laws, was approved by the Board of Directors, and in accordance

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CHICAGO 38, ILLINOIS

FORGING PRESSURE IN YOUR WELDING PROBLEMS

rating:

150 KVA at 50% duty cycle. Single phase alternating current of one voltage and one frequency. Power supply may be 440 or 220 volts, 60, 50 or 25 cycles, according to the user's specifications.

performance:

CAPACITY: As a projection welder—6 projections on .080" plus .080"—distance between welds ¾"; projections in accordance with RWMA standards. Maximum current on secondary side, 31,000 amps. with a distance of 11½" between arms. As a spot welder—(electrode holders optional equipment) stainless or clean mild steel from .032" plus .032" up to and including .187" plus .187".

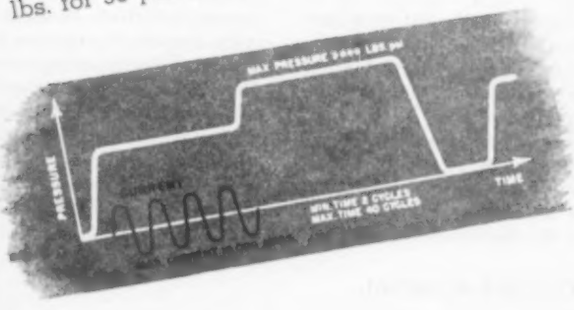
SPEED: 180 welds per minute on .032" plus .032" pickled mild steel.

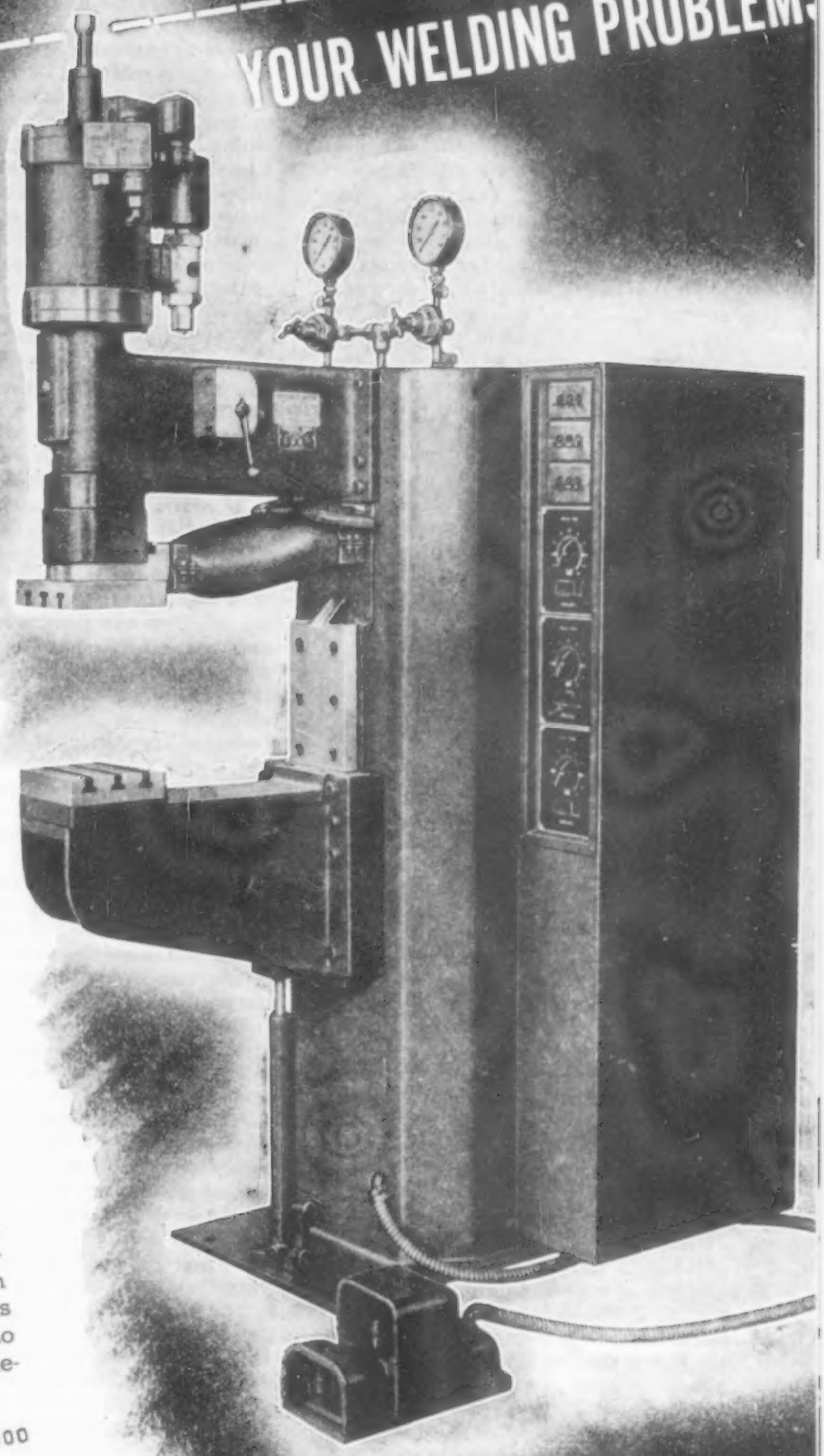
THROAT DEPTH: 18" from center line of welding ram to face plate.

CLEARANCE BETWEEN ARMS: Lower arm adjustable over a range of 11½". Maximum working space between arms 21".

ELECTRODE STROKE: Adjustable stroke, retractible head, permits a working stroke of ½" with foot controlled retraction to give a total opening up to 2¾". Selection of constant working stroke, or working stroke with retraction is through toggle switch mounted on control panel. The retraction feature is designed for spotwelding. It may also be used for projection welding if desired.

WELDING PRESSURE: Maximum 3000 lbs. for 90 psi. line pressure.





PMC01-9
projection welder

IN 120-A

with Article VI, "Amendments," of the Constitution, the membership of the SOCIETY will be asked to vote on this amendment of the Constitution at the Business Session of this Annual Meeting.

In connection with its study of the Constitution and By-Laws, the By-Laws Committee reviewed Rulings of the Board of Directors. As a result of the Committee's recommendations, some Rulings have been made part of the By-Laws, others have been abolished, and some have been added. Revised Rulings were published in the 1945 Year Book. Since publication, the Board has ruled that Executive Committee members be invited to meetings of the Board of Directors.

The By-Laws Committee recommended needed changes in the draft of by-laws suggested for Sections of the AMERICAN WELDING SOCIETY so as to make it conform with the revised edition of the By-Laws recently adopted. The Committee also reviewed and approved by-laws submitted by the newly established Tidewater, Michiana and Bridgeport Sections.

During the year, the Public Relations Committee has been called upon to make recommendations to the Board of Directors with respect to a number of items as follows:

1. A general policy to be followed by the SOCIETY where specifications, regulations or directives issued by other societies or agencies and such are considered to be ill-advised, incorrect or otherwise detrimental to the best interest of the welding industry.
2. AMERICAN WELDING SOCIETY cooperation with the National Safety Council Committee on Planning for Safety in Industry.
3. A request that the AMERICAN WELDING SOCIETY support an effort to induce Navy Yards and other Navy departments to recognize welding as a definite trade in and by itself.
4. U. S. Maritime Commission directive requiring the preheating of joints to be welded in cold weather.
5. Interstate Commerce Commission Specifications that do not provide for the fusion welding of longitudinal seams on compressed gas cylinders.

With the exception of the one relating to the I.C.C. Specifications, the Committee's recommendations were adopted. Through the adoption of these recommendations, a general policy was established in regard to restrictive or ill-considered specifications promulgated by other societies which, in effect, instructs that questions relating to such specifications or regulations be referred to the proper A.W.S. committee for investigation and report back to the Board of Directors for action; cooperation was offered to the National Safety Council Committee on Planning for Safety in Industry; and the United Federal Workers of America's request for support in inducing Navy yards and other Navy departments to recognize welding as a definite trade in and by itself, was treated in accordance with A.W.S. established policy, namely, not to render information on questions relating to labor or labor organizations nor to enter into any controversy that affects these questions.

The Board of Directors decided that questions arising in connection with ICC Specifications be handled in accordance with A.W.S. general policy established in respect to restrictive or ill-advised specifications or regulations.

In addition the Public Relations Committee, through a subcommittee consisting of members of the Public Relations Committee and members of interested technical committees, is working on a project designed to bring the requirements of the New York City Building Code in accord with up-to-date standards of the AMERICAN WELDING SOCIETY.

Finances

Since this report is being written in advance, it cannot reflect the experience of the full fiscal year. As in previous years there will be a final report after the closing of the fiscal year, which will be published in the SOCIETY'S Year Book.

A continuing substantial growth in membership and increasing income from THE WELDING JOURNAL advertising, and sales of printed matter of various sorts, with due allowance for a consequent but considerably less than proportionate increase in expenses, has brought the SOCIETY'S financial position to a new high level.

For the first 11 months of the fiscal year there has been a betterment over the budgeted expectation of $31,324.52 and a net excess of income over expenses of $38,898.24, after deduction for the mandatory 1% of gross income that is transferred each year to the Permanent Reserve Funds of the Society.

In view of the current cash position on May 31st, $10,000 was transferred, by direction of the Board of Directors, to the Permanent Reserve Funds, in addition to the mandatory transfer mentioned in the preceding paragraph.

The Finance Committee held two meetings during the year. These were devoted to discussion and approval of the financial report of the SOCIETY for the fiscal year ending September 30, 1944, preparation of the budget for the fiscal year ending September 30, 1945, discussion of the Annual Meeting Budget, consideration of the proposed addition to the staff of an Editor for the *Welding Handbook*, and general study of the financial operations of the SOCIETY.

The Annual Meeting Budget, as presented by the Convention Committee, was reduced greatly from previous years because of the greatly abbreviated nature of the meeting that is to be held in accordance with U. S. Government regulations.

The Special Committee appointed to build up the Permanent Reserve Funds, because of other demands upon the time of its members, found little opportunity to develop its program during the first half of the fiscal year. The results of its activities, therefore, will not be apparent until the close of the year, and will be given in a final report.

During the year the Permanent Funds Committee invested $17,500 in U. S. Treasury 2½% Bonds, of which $10,000 came from the Permanent Reserve Fund and $7500 from the Special Reserve Fund. The total invested resources of the Committee as of August 31, 1945, amount to $74,707.11. In addition, there is a cash deposit in the Reserve Fund Special Account of $5740.85.

Membership and Sections

Membership Activities.—To fulfill the need for disseminating welding information and providing opportunity for interchange of ideas, many new Sections sprung up these past four years in war production centers, particularly in shipbuilding centers. All served a very useful purpose. However, since the membership of these Sections is made up almost entirely of those engaged in war production, on termination of the war, need for some of them is disappearing. There are indications in this direction already, and while we are losing members who are going into other industries, we are gaining some from centers now engaged in reconversion production.

The gain in membership during the past year has been 28%, offset by a loss of 20% due mostly to occupational changes, deaths and the like, making a net gain for the year of 8%. Gains and losses in the various classifications in terms of percentages are given below:

	Increases	Decreases	Net Gain
Sustaining Members	17	7	10
Full Members	27½	12	15½
Associate Members	34	16	18
Operating Members	3½	76½	73*
Student Members	30	35	5*

* Loss.

Membership statistics for membership year ending August 31, 1945, are shown below:

	A	B	C	D	E	F	Total
Total membership, August 31, 1944	127	2812	4108	740	2	20	7809
Gain (new members, increases in classifications and reinstatements)	22	778	1394	26	..	6	2226
	149	3590	5502	766	2	26	10035
Loss (resignations, cancellations because of delinquency and decreases in classification)	9	341	654	567	..	7	1578
Total membership August 31, 1945	140	3249	4848	199	2	19	8457
Net changes during year	13	437	740	−541	..	−1	648

Districts and Sections.—Through the successful efforts of some of our District Vice-Presidents and interested groups in the localities, Sections have been organized during the year in Hartford, Michiana, Northwestern Pennsylvania and Tacoma. Other Sections were revitalized. For reasons mentioned above, the following Sections will be disbanded: Brunswick, Lake Shore, Mobile, Portland, Me., and Savannah.

The majority of the Sections are to be congratulated on their splendid accomplishments this past year. Technical meetings, educational programs and social events have done much to enhance the SOCIETY'S prestige as a technical society. Interest in these sessions continue at a high level and the attendance in most cases was excellent. There are a few centers where help is needed but the feeling is that if the incoming District Vice-Presidents, with the assistance of Headquarters, will continue work started this year, we can look for a decided improvement next year. This year's District Vice-Presidents are to be commended for the time and effort they have spent on their assignments and on the efficient and effective manner in which they have handled this work. In most cases, they have been in close touch with the Section officers, straightened out difficult situations, inspired the rebuilding of inactive Sections and the formation of new Sections. Complete reports on conditions in the Sections have been reported to Headquarters at the close of the year and it is planned to turn them over to the new officers for their guidance in planning future work. We are deeply indebted to these men and to the Section officers for their promotional efforts. It is fitting that special mention be made here of the work of Mr. Henry C. Neitzel, Detroit Section Membership Committee Chairman, who has been responsible for that Section having the largest number of members at the close of this fiscal year.

The Section Advisory Committee has acted to advise the National Board of Directors on matters affecting the Sections, and acted to transmit and report upon various matters referred to the membership through the Section Organization. It has kept the Sections advised on developments and actions of the National Board and the Convention Committee with respect to the resolution presented at the Sections Conference at the 1944 Convention, favoring an independent annual meeting and welding exhibit.

Early in the year action was taken to obtain the reactions of the Sections to revisions in the By-Laws of the SOCIETY. Similar action was taken on membership application forms, particularly those for Student Members and Sustaining Members.

There was also referred to the Committee a Guide for Organization and Operation of Sections, and a recommendation that the Past Chairman's Pin be replaced with a certificate.

The most comprehensive subject handled by the committee this year was that of establishing boundaries for the various Sections. This was accomplished by assigning to each District Vice-President the responsibility for boundaries in his District. He in turn is to request each Section to designate the territory it thought should be assigned to it.

The area generally was assigned without question, unless an overlap developed, in which case the District Vice-President worked out with the Sections involved, any such questionable points, keeping in mind that territory is not assigned as exclusive, but that the By-Laws permit considerable elasticity in that a member may elect to join some nearby Section because transportation or business interests may make membership in such other Section more desirable to him.

Based on the above, Districts 1, 2, 4 and 5 have been practically completed, but Districts 3, 6 and 7 have not yet produced results.

The boundaries of those Sections which have been completed have been approved by the Board of Directors, subject to a few minor proposed changes.

In compliance with ODT request to keep down attendance at conventions, plans are to hold a meeting of the Section Advisory Committee in place of the usual Section Officers' Conference.

During the year a number of Sections have been visited by the President and National Secretary, in addition to visits of the District Vice-Presidents. Some District Vice-Presidents have made it a point to cover every Section in their District. This has been found most desirable and has resulted in improving the operations of the Sections and increasing their activity.

The President's visits included the Philadelphia, York, Pittsburgh, Louisville, New York and Cleveland Sections, and the Secretary's visits included the Washington, Detroit, Philadelphia and New York Sections. With the removal of travel restrictions, it is hoped this coming year a greater number of Sections can be visited.

Application Forms for Membership

The Special Committee on Application Forms prepared a revised form for the Member and Associate Member grades which, after approval by the Board of Directors, became standard and is now in use. The committee has under preparation also forms for the Sustaining Member and Student Member grades which, together with recommendation for further changes in the standard Member and Associate Member forms, will shortly be presented to the Board of Directors for adoption.

On recommendation of Special Committee on Membership Application Forms, the Board of Directors voted that upon completion of forms for the Sustaining, Student, Member and Associate Member grades, the Special Committee be discharged and the scope of the By-Laws Committee be expanded to include matters of this kind.

Admission to Membership

Pursuant to the changes in By-Laws adopted by this SOCIETY, the Committee on Admission to Membership suggested a working arrangement whereby the National Secretary of the AMERICAN WELDING SOCIETY could pass on all normal applications for membership, acting for the committee in line with the rules established in the By-Laws, Article II, Sections 2, 3, 4 and 5, and Article III, Section 1.

No unusual activity of this committee occurred during the past year.

Publications

Welding Journal.—The number of printed pages published in the calendar year 1944 was 1934 as against 1772 in 1943. The first 9 months of the calendar year 1945 are ahead of the same period in 1944 by 22 pages. In order to keep within the paper restriction, the weight of paper had to be reduced four times and it was necessary to trim the margin of the JOURNAL. For the first time in its history, the JOURNAL in August of this year was forced to suspend publication of Section Activities, List of New Members and to curtail other sections. These sections have now been resumed.

During the year the Publication Committee sent out a comprehensive questionnaire to gage the interest of the readers of the JOURNAL in each of its various departments. The results were extremely gratifying to the Board of Directors and the Publication Committee of the Society. In general, it was found that the various sections of the JOURNAL were meeting the needs of the membership to a satisfactory degree and no important change was warranted.

Advertising returns and circulation of the JOURNAL reached new highs.

This year the operation of a "Convention by Mail" throws new burdens on the Editor, but these are not expected to result in any unusual difficulties.

The JOURNAL continues to cooperate with other technical journals, both in granting of reprint rights and in securing pertinent technical and research information from sister societies here and abroad.

The Publication Committee and the Editor, at all times, welcome constructive suggestions for improvement. Acknowledgment is also made for the excellent cooperation, financially and otherwise, of the Welding Research Council.

Welding Handbook.—The 1942 Welding Handbook Committee rendered its final report last January. It showed the book was an outstanding success financially and technically. The financial return was such that it was possible to turn over $10,000 to the permanent funds of the SOCIETY and still leave the Handbook account with a sizable cash balance.

Upon exhaustion of the first 12,000 copies printed, a second printing of 5000 copies was made necessary. Sale of the second printing is proceeding satisfactorily so that there is every reason to believe all copies will be exhausted by the end of 1947, when it is hoped the new edition becomes available. Heretofore, the cost of overhead has not been made a charge against the *Welding Handbook*, as it was estimated to be equivalent to the amount of the cost of furnishing each "Member" and "Sustaining Member" with a free copy of the book. Inasmuch as no additional staff was added, this arrangement favored the SOCIETY account rather than the Handbook account. On recommendation of the 1942 Welding Handbook Committee, the SOCIETY will now absorb the operation of the Handbook as a regular and continuing part of the SOCIETY'S activities and the expenditures connected therewith will be budgeted each year as a regular activity, similar to other functions of the SOCIETY. The data available in the SOCIETY'S files will serve as a guide.

On recommendation of the 1942 Handbook Committee, the Board of Directors

appointed a new Handbook Committee, and authorized employment of the full-time services of an individual to handle the preparation, publication and sales of future Handbooks, who, in interim periods between Handbook publication, can handle the preparation, publication and sales of other educational books authorized by the SOCIETY.

The new Handbook Committee, composed of H. C. Boardman, *Chairman*, W. F. Hess, C. H. Jennings, C. W. Obert and F. L. Plummer, together with the former editor, W. Spraragen, and the Treasurer, O. B. J. Fraser, are giving consideration to the editorship, budget and outline of chapters for the revised handbook.

Other Educational Books.—The great demand for books entitled *Welding Metallurgy*, *Practical Design for Welded Steel Structures*, *Guide to Weldability* and *Glossary of Foreign Welding Terms*, as well as for our codes, standards and specifications continues, as evidenced by the sale of these books and standards. A revision of the book entitled *Welding Metallurgy* is under way and expectations are that the revised edition will be ready some time next year.

During the year the Special Committee on Recommended Procedure for Publishing Educational Manuscripts in Book Form approved the publication in pamphlet form of a translation of a German book by Prof. Kilger on Flash Welding. This book is being published serially in THE WELDING JOURNAL. The translation was made by the National Defense Research Council. The book will sell for $1.00 per copy.

A format was developed for the publication of the Adams Lecture series. The 1944 Adams Lecture by Dr. A. B. Kinzel on Pressure Vessel Welding has already been made available.

In general, the publication of these educational books has paid for itself. In some special instances, considerable profit was derived by the SOCIETY.

Inasmuch as the Board of Directors approved the employment of a full-time editor for the Handbook and other educational books, this special committee is requesting the new administration to give consideration to its discharge.

Foreign Libraries.—As reported to you last year, a definite plan for handling requests for publications coming from foreign libraries was postponed until the postwar outlook is clear. In the meantime, it was decided that since the American Library Association through its knowledge could act more discriminatingly toward foreign library requests than could the SOCIETY, it was agreed, on recommendation of the special committee appointed to handle requests from foreign libraries, to furnish the American Library Association with ten sets of the WELDING JOURNAL and other SOCIETY literature without charge, with the understanding that these copies would be given free to deserving foreign libraries and research institutions, and with the further understanding that the American Library Association would keep the SOCIETY informed of the disposition of these publications so as to avoid duplication in fulfillment of requests for free copies and subscriptions. No matters have come up for action by the committee this past year. However, it can be recorded that orders for our various publications from foreign countries are increasing daily.

Meetings

1944 Annual Meeting.—The 1944 Annual Meeting was held in Cleveland, Ohio, on the occasion of the 25th anniversary of the SOCIETY. As in previous years, the program was curtailed to $3^1/_2$ days, with all social functions eliminated. The entire time was again devoted exclusively to technical and educational sessions, standardization and research conferences and committee meetings. The registration of 1720, although not the greatest in the SOCIETY'S history, was considered very good, in view of the unusual difficulties of traveling and securing train and hotel reservations.

The 25th Anniversary Technical Program was a high spot in the history of the AMERICAN WELDING SOCIETY. Addresses by Colonel S. B. Ritchie, of the Office of Chief of Ordnance, and Admiral H. L. Vickery (through Mr. Martinsky), of the U. S. Maritime Commission, gave public acknowledgment to the role played by welding in the war effort and the part played by the SOCIETY. A total of 58 papers were presented at 19 sessions, with a record attendance at these sessions.

1945 Annual Meeting.—At their meeting held on October 19, 1944, the Directors approved the recommendation of the Manufacturers Committee that no exhibits be held for the duration of the war and authorized the Convention Committee to proceed with plans for technical sessions to be held in 1945, in conjunction with the National Metal Congress, provided satisfactory arrangements could be made and provided the National Metal Congress was held in 1945 and A.W.S. was invited by A.S.M. to participate.

The Convention Committee, therefore, proceeded on the basis that a National Metal Congress would be held in 1945 and kept in close touch with A.S.M. which was developing its plans along similar lines. At its meeting held on February 7, 1945, the Convention Committee recommended to the Program Committee that it proceed with the preparation of the technical program for the 1945 Annual Meeting on the same basis as for previous years. If a meeting of regular type could not be held the papers received would be published in the WELDING JOURNAL and be well broadcast to the industry, in any case, so that the authors would be rewarded for their efforts.

During the spring, the restrictions placed on travel and conventions by O.D.T. became steadily more severe. The Convention Committee, at a meeting held on June 20, 1945, considered a letter received from A.S.M. advising that they saw no immediate prospect of being able to hold either a convention or exposition and that they planned to hold their Annual Meeting in cooperation with their Cleveland Chapter, for the installation of officers, awarding of medals and rendering of annual reports.

Under the circumstances, on recommendation of the Convention Committee, the Directors authorized proceeding with plans for a meeting in 1945 separate from A.S.M., this to be a one-day meeting held in cooperation with the New York Section in the Hotel Pennsylvania, New York City on Thursday, October 18, 1945.

The 26th Annual Meeting will be held as a "Convention by Mail," in so far as the technical papers are concerned. A careful program has been developed for stimulating written discussion on the papers selected. By a ruling of the Board of Directors, these papers will be eligible for consideration of awards and prizes just as though they had been presented orally. Local Sections of the SOCIETY will be encouraged to utilize these papers for local Section meetings. The Program Committee has arranged for the inclusion of 62 papers, classified under 16 general subjects.

Separate Exhibit

The question of a separate Welding Exposition is being actively investigated. Everyone realizes that such a step would not be possible without elaborate planning, adequate financing, and sponsorship by some responsible organization. The latter probably would have to be organized for the purpose. This study will not be completed until fall.

Due recognition is here given of the invaluable services rendered by the officers of the Convention, Manufacturers, Program and Publicity Committees in making the Annual Meetings a success.

Publicity

During the year a total of 11 releases have been prepared and sent to the active mailing list of more than eighty trade and technical magazines, news associations and selected metropolitan newspapers. Copies were also furnished to Local Sections for any use which they might be able to make of them in local area newspapers.

Annual Meeting Publicity.—Since wartime conditions made it impossible to plan for the 1945 Annual Meeting on the usual basis, preliminary publicity on the one-day Meeting decided upon by the Board of Directors was confined to an announcement of the date of the Meeting and the program arranged. Full coverage will be given to the election of new officers, the winners of the various SOCIETY awards and prizes, and the Adams Lecture. The coverage this year will include educational, fraternal and other publications which the National Officers elected have indicated might be interested in having such information.

Welding Research Council.—At its member meeting the Publicity Committee directed its secretary to work in cooperation with the Director of the Council in preparing publicity material covering Council matters. This has been done and special emphasis will be placed upon publicizing completed projects of the Council as they are approved for general dissemination.

Increasing Membership Interest.—The committee has studied its proper relation to the work of the Membership Committee and has directed its secretary to cooperate in the preparation of material which, in addition to its value in at-

tracting interest in SOCIETY membership, is a legitimate publicity function. Two such fields of joint effort have been decided upon. The first is a digest of the Annual Report of the SOCIETY which will be sent to the regular mailing list and, in addition, will be used as a filler piece in follow-up letters sent to members who are late in paying their annual dues. This report will serve as a reminder of the scope of SOCIETY activities and the values derived from membership.

The other tentative proposal was that, with Local Section approval, the Publicity Committee's secretary would cooperate with the Acting Technical Secretary of the Society in preparing summary statements concerning the activities of the various technical committees of the SOCIETY.

The preparation of these summaries on the general technical activities of the SOCIETY, on the Code of Minimum Requirements for Welding Operators and on the latest filler metal specification has been completed and the releases sent to the Sections and the regular mailing list of the Publicity Committee.

Clipping Service.—A review of the clippings which were received from a clipping service, plus a review of the files of trade and technical magazines maintained by one of the committee member's company, indicates that the national releases are being used, in most cases as received, by the trade and technical press. This was to be expected inasmuch as the publications now on the mailing list are all ones which have indicated their desire to receive such releases. All were surveyed about a year and a half ago when the present mailing list was prepared and only those publications indicating a desire to receive information about SOCIETY'S matters were included on the revised list.

Local Section Publicity Activities.—A list of suggestions, prepared by this committee, about ways in which local press cooperation may be obtained is furnished to new Local Section Chairmen when Headquarters receives notice of their election. This suggestion list was first sent out in 1944 but the clippings received do not indicate that much action has been taken in following out the suggestions made. A total of 105 Local Section items were received from our clipping bureau in the year 1943–44 and a total of only 127 in the year 1944–45. Only 17 Local Sections were represented in the latter year.

A further indication that still greater interest in this matter would be desirable is the fact that reply post cards were received from only 11 Sections when they were requested to inform the committee of the names of their Local Publicity Chairmen.

Education

Your Educational Committee's activities have been confined this year to the making of a survey of available motion pictures, slide films and other instructional material available from welding manufacturers, that might be useful for instruction of engineering students. From the data received, the committee will compile a list of such materials for wide distribution among the instructional staff of engineering schools over the country.

A letter prepared by the Educational Committee, and sent out over the signature of the President of the Society, was sent to the Deans of engineering schools on the subject of the place of welding in engineering education. The tenor of replies received from the Deans indicated interest and, in some instances, a desire for assistance.

Also, your Committee is making a systematic survey of textbooks in the various fields in which welding is introduced into engineering curriculum. Textbooks which are presently being studied include those in the fields of structural design, machine design, materials of engineering, metal processing and metallurgy. Some thought is also being given to a thorough analysis of present courses to determine how those courses already in engineering curriculum might be broadened advantageously.

The Committee plans when the survey is complete, to offer suggestions to publishers for better coverage of welding. Publishers have already been contacted and have indicated a willingness to cooperate.

The Committee is also considering the preparation of a letter to the Civil Service Commission setting forth educational requirements for welding industry.

Awards

The Committee on Awards has given careful consideration to the various duties assigned to it and has presented to the Secretary of the SOCIETY its nominations for Adams Lecturer, Miller Medallist and Lincoln Medallist. The Committee has also prepared the wording for the presentation of Honorary Memberships to the three candidates selected by the Executive Committee. All members have taken active interest in these duties which has made it a real pleasure for the Chairman in coordinating the work.

The following selections have been made to date:

Samuel Wylie Miller Memorial Medal—J. H. Deppeler
Lincoln Gold Medal—L. C. Bibber

On recommendation of the Awards Committee, Dr. W. F. Hess was unanimously approved by the Board of Directors as the 1946 Adams Lecturer.

The Jury of Award of the R.W.M.A. 1945 Prize Contest has selected as this year's winners the following:

$500 Prize for the best paper emanating from an Industrial source in which the major portion of the subject matter is concerned with design for resistance welding, has been awarded to Mr. L. A. McIntosh, for his paper on "Resistance Welding for Economy and Quality."

$200 Prize for the best paper emanating from a University source has been awarded to Messrs. W. F. Hess, R. A. Wyant and B. L. Averbach, for their paper on "The Surface Treatment at Room Temperature of Aluminum Alloys for Spot Welding," published in the September 1944 *Supplement* of THE WELDING JOURNAL.

$200 Prize for the best paper emanating from an Industrial source has been awarded to Messrs. G. W. Scott, Jr., L. G. Sutton and J. H. Widmyer, for their paper entitled "Radiography for Development and Control of Aluminum Alloy Spot Welding," published in the November 1944 *Supplement* of THE WELDING JOURNAL.

$100 Prize has been awarded to Mr. J. C. Barrett, for his paper on "Flash Welding of Alloy Steels—Physical and Metallurgical Characteristics," published in the January 1945 *Supplement* of THE WELDING JOURNAL.

Honorable Mention:

H. W. Brown, for his paper entitled "The Spot Welding of 0.0375-In. Aluminized Low Carbon Steel," published in the September 1944 *Supplement* of THE WELDING JOURNAL.

E. M. Callender, for his paper, "Small Portable Condenser Welding Set," published in the October 1944 WELDING JOURNAL.

F. R. Hensel, E. I. Larsen, E. F. Holt, for their paper, "Problems in Spot Welding of Heavy Mild Steel Plate," published in the January 1945 *Supplement* of THE WELDING JOURNAL.

By unanimous vote of the Board of Directors, the following members have been added to our Honorary Membership list:

H. C. Boardman
J. H. Deppeler
D. S. Jacobus

Enlargement of Society Headquarters

For some time the offices of the AMERICAN WELDING SOCIETY have been entirely inadequate. Our repeated efforts to acquire additional space in the Engineering Societies' Building in New York finally met with success this past year, and in August 1945 we moved into bigger quarters on the sixth floor of the Engineering Societies' Building. Through the acquisition of this additional space, adjoining our present offices, the SOCIETY is able to house its staff in a manner more fitting to a society of its standing and size.

Deaths

The Society this past year has suffered severe losses through the deaths of two of its Past-Presidents, Messrs. G. T. Horton and Edmund A. Doyle, and through the deaths of Mr. Claude J. Holslag, a founder member, and Prof. A. V. DeForest, whose keen interest endeared him to all. Resolutions were adopted by the Board of Directors and transmitted to their families and companies. The deaths of Mr. W. S. Evans, District Vice-President-Elect, and Mr. H. M. Boetcher, founder member of the Maryland Section, were also recorded and suitable obituary notices carried in the JOURNAL columns.

Employment Service

For the benefit of the SOCIETY membership and the welding industry, a column in THE WELDING JOURNAL is devoted each month to Positions Vacant and Services Available. We are able to include only those coming to the attention of Head-

quarters. We shall be glad to have more members take advantage of this service.

Acknowledgments

Opportunity is here taken to express our debt of gratitude to the National District and Section Officers and Committees for the serious and wholehearted interest they have shown in the trust placed in them; to thank our membership, Sustaining Members in particular, and JOURNAL advertisers for their genuine interest and support; and to express appreciation to the staff for their helpful cooperation this past year.

Research

A report on the research activities is given on the last page of the Research Supplement.

Technical Activities

A full account of the Technical Activities will appear in the December issue of the Welding Journal.

GAS RANGE OF TOMORROW

A contest for the design of the "Gas Range of Tomorrow," involving 16 cash awards totaling $18,000, will be conducted by the American Stove Co., S. E. Little, vice-president, has announced.

Reason for the competition is effectively outlined in the attractive rules booklet which has been prepared by its sponsors for the use of contestants: a reason which may forecast a new postwar trend involving participation of the ultimate user in the specific design of home appliances.

"The Magic Chef gas range of today," the booklet states, "represents the ultimate in cooking service to date, but out of this war have come new materials, new processes, new designs and new ideas which may make possible a new and different gas range for the future—more beautiful, more convenient, more practical, and one which will bring the Homemaker more freedom from cares and cooking problems . . .

The contest imposes few limitations on the designs. It must, of course, be a stove of style and beauty that will fit into the general scheme of the home of tomorrow.

The contest is open to all residents of the United States, with the exception of the American Stove Co., its subsidiaries, its advertising agencies, The Architectural Forum and the families of such employees, or employees of other range manufacturers.

The cash awards are broken down as follows: 1st prize, $5000; 2nd prize $3000; 3rd prize, $2000; three prizes of $1000 each; and 10 prizes of $500 each. The contest opened in November and closes March 1, 1946.

Awards will be made by a jury composed of architects, designers and home economics experts. Contestants may submit drawings in black and white, or in color. There are no limitations on either the scale or types of drawings submitted, although they must be submitted on 18- x 24-in. sheets.

The competition booklet, which also incorporates the basic technical data required in initiating a design, may be obtained free of charge by writing to George Nelson, A.I.A. c/o The Architectural Forum, Dept. P-3, Empire State Bldg., 450 Fifth Ave., New York 1, N. Y., mentioning the Magic Chef design contest.

LUKENS STEEL NAMES BROWN TO HEAD PITTSBURGH OFFICE

Arthur H. Brown, who has been associated with Lukens Steel Co. and subsidiaries, By-Products Steel Corp. and Lukenweld, Inc., Coatesville, Pa., since 1930, has been named Manager of Sales for Pittsburgh and vicinity, according to an announcement made by J. Frederic Wiese, vice-president in charge of combined sales for the three companies. The appointment was effective as of Monday, October 15th. Brown is making his headquarters at Suite 2000, 429 Fourth Ave. near Grant St., in downtown Pittsburgh.

Brown, a native of Coatesville, has served in the Coatesville District Sales Office. Previously, from 1939 to 1943, he was associated with the New York sales office. He has served also as a member of Flanging Sales and Plate Sales Departments, as well as with the Mechanical and the Standards Departments of Lukens in Coatesville.

Brown, who was graduated from Coatesville High School, also attended Manhattan College, New York; Brooklyn (N. Y.) Polytechnic Institute, and Penn State College extension courses. He has been active in the York-Central Pennsylvania Section of the AMERICAN WELDING SOCIETY, currently serving as chairman of the program committee.

COMMUNICATION TO THE SOCIETY

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON 25

October 4, 1945

American Welding Society
Attn.: Mr. Simon A. Greenberg, Acting Tech. Secy.
29 West 39th Street
New York 18, N. Y.

Subject: National Directory of Commodity Specifications.

Dear Sir:

We have recently forwarded to the Government Printing Office the manuscript for the revised edition of the National Directory of Commodity Specifications. Your organization contributed much valuable material used in this publication.

Considerable effort has been made to increase the usefulness of this Directory. The first edition, issued in 1925, only listed the title, designating number, and name of the organization issuing the specification. The second edition, issued in 1932, also included brief summaries of the specifications. The present revised Directory, containing more than 1300 pages, gives summaries showing the scope, technical characteristics, and application of each specification in order that the user may select the one best suited to his particular needs.

We have requested the Superintendent of Documents of the Government Printing Office to forward a copy of this Directory to you for your official use. We should appreciate it if you would call the Directory to the attention of the members of your organization and would keep our name on your mailing list so that we may receive copies of your future specifications as they are issued.

Orders should be sent to National Bureau of Standards (Misc. Pub. M178), National Directory of Commodity Specifications. Price $4.00. Foreign $5.25.

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